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EDITORIAL NOTE.

SOIL EROSION.

As readers of the *Tea Quarterly* are aware, a Committee appointed by Government has recently been collecting evidence regarding soil erosion and the means of dealing with this problem. The subject is one of importance to most tea estates and merits the fullest discussion and consideration as, there is some reason to believe that the seriousness of the losses incurred is by no means generally appreciated. In the present issue of the *Tea Quarterly*, therefore, a considerable amount of space is devoted to the subject. The ground covered by the Committee's enquiry is indicated by the Questionnaire issued by it of which we reprint those portions relating to tea. Following this will be found the Memorandum in which was presented the evidence of the Tea Research Institute. A summary of the views there expressed has already been published in the press in the form of a lecture given before the Dimbula Planters' Association by the Director of the Institute in December last.

From certain correspondence which subsequently appeared in the press, it is evident some misunderstanding exists in the minds of a few of our readers regarding one or two points raised in our evidence. It is clear that such misunderstanding arises from a misconstruction of certain passages of the evidence considered out of context with the document as a whole, and we see no reason from the arguments put forward to modify our views. We have, however, considered it desirable to amplify our original evidence in order further to elucidate the points questioned, and the Supplementary Memorandum prepared for this purpose will also be found in the present number.

From a consideration of these two memoranda it will be seen that the view of the Institute is that for the prevention of soil erosion reliance must chiefly be placed on an extended use of cover crops. At the same time, we believe that an important second line of defence consists in the utilisation of improved systems of drainage, calculated to decrease the rate of water movement, allowing time for percolation and for the settlement of the finer particles of suspended soil. In our memorandum attention in regard to drains was naturally focussed on the Felsinger and du Pré Moore systems. This must not, however, be taken to indicate that we regard either of these systems as the final solution of the problem. In fact, in our memorandum we clearly showed their limitations. But we regard the principles underlying these systems as fundamentally sound, though the application will vary in different districts in accordance with local conditions of soil, slope and intensity of rainfall.

In the minds of many planters a dislike to cover crops is apparently based on (1) the belief that such crops enter into competition with the tea by removing manurial ingredients which, it is considered, will no longer be available for the tea, and (2) the fear that inconvenience may be caused by the cover crop getting into the plucking table. These fears are undoubtedly exaggerated and have probably little real foundation with proper management of the cover crop. With regard to (1), the use of cover crops carries the implication that such crops will be cut at appropriate intervals and incorporated in the soil. Decay then sets in when the manurial ingredients, previously removed, are returned to the soil and become again available to the tea. In regard to nitrogen particularly, it is probable that cover crops, quite apart from any question of nitrogen fixation, lead to a definite conservation of plant food. For nitrogen in the form of nitrates, in which it is utilised by most plants, is readily leached out of the soil, and there is much less chance of loss occurring if nitrates are gradually set free in the soil, as occurs by the breakdown of the organic matter of a cover crop, as they can then be utilised by the tea before opportunity for serious loss by leaching or other causes occurs. In regard to (2), proper management and control of any cover crop is, of course, required. The necessity for such control is fully appreciated by planters in the case of high shade, and it is not clear why its importance in the case of cover crops should be less generally recognised. It may be argued that such management involves extra labour and expense. As an offset to this the resulting improvement in soil condition must be taken into account. It is considered that such improvement, including as it does an increase in the content of organic matter and humus in the soil, may well result in diminished expenditure on artificial manures. If this view be correct, the total cost of manure and cultivation will not be increased, and it is a matter for serious consideration whether the utilisation of a larger proportion of such expenditure on cultivation and soil management rather than manures would not have results highly beneficial to the tea. It cannot be too strongly emphasised that cover crops confer many other advantages apart from their beneficial effect in regard to soil erosion, and the attention of readers is invited to an article by Mr. Eden in the present number on Green Manuring and to a previous article (*Tea Quarterly*, 1929, 2, 96,) in which this aspect of their use is more fully discussed.

The opinions expressed in the Institute's memorandum receive considerable support in a subsequent Bulletin issued by the Imperial Bureau of Soil Science, reviewing modern research on soil erosion in many countries. The data there presented are most striking, and the more important are summarised in a review in the present number.

ROLAND V. NORRIS.

CEYLON SOIL EROSION COMMITTEE—QUESTIONNAIRE.*

1. Do you consider that soil wash is serious on your estate ? State whether you have had claims from owners of paddy fields, and whether opening of new clearings has resulted in the drying up of springs or streams.
2. Are you in favour of clean weeding (a) in new clearings, (b) in old tea, rubber, or coconuts ? (Note—By clean weeding is meant the absence of *all* ground cover other than the crop being grown). Give reasons for or against, and state whether you consider that clean weeding increases the rate of leaching of artificial manures. Do you consider that the benefits derived from clean weeding compensate for the soil lost by erosion ?
3. What steps have you taken to prevent erosion ? Discuss them briefly under the following headings:—
   (a) Use of high shade
   (b) Drains and silt-pits
   (c) Contour terraces and platforms
   (d) Contour hedges
   (e) Ground cover
   (f) Contour planting of major crop.
4. Which of the methods you have tried or have read of do you consider the most efficient in preventing soil wash ? Do you consider that you have done all that is necessary to prevent soil wash ?
5. Have you any experience (apart from contour drains, high shade or ground cover) of stone terracing, bunding above drains or other anti-erosion methods in areas already planted up ? Have you any experience of platform terracing in tea ?
7. Are you familiar with du Pré Moore's or Felsinger's systems ? Or Denham Till's contour trenches ? Have you tried any of these methods ?
8. In work of this kind in areas already planted up, would it be necessary to sacrifice any trees ? If so, what percentage ? Do you consider that root damage would be serious ? How would you propose to obviate such damage ?
9. Have the above-mentioned methods any disadvantages ? If they bring about a decrease of soil erosion, do you consider that the decrease of wash outweighs the disadvantages ?

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* The above questions, upon which the Institute's evidence was based, comprise those from the Committee's questionnaire which are applicable to tea. The numbers correspond with those in the original document. Paragraph 6 which was concerned with rubber is omitted.

10. How do you treat new clearings as to:—
    (a) Direction of planting ?
    (b) Provision of temporary or permanent shade and cover ?
    (c) Prevention of erosion in general ?
11. Are you in favour of compulsory legislation for the adequate protection of the soil against erosion ? Do you consider that such methods would be feasible ?

MEMORANDUM ON SOIL EROSION

EVIDENCE SUBMITTED TO THE SOIL EROSION COMMITTEE BY THE TEA RESEARCH INSTITUTE.

As a preliminary to the consideration of methods of combating soil erosion, it is advisable to review briefly a number of soil properties which contribute to, or tend to prevent, soil wash.

(1) PARTICLE SIZE.

Eroded soil contains particles of varying size according to the severity of climatic conditions and of land contour, but by far the most important fraction of this soil is what is analytically designated "clay." This fraction is the most chemically active of all, and is the seat of many of the processes that provide the available nutrients for the crop. The particle size of clay is very small, its diameter according to the latest convention being 0·002 mm. (less than one-ten thousandth of an inch). Consequently, it is easily held in suspension by water for considerable periods, and when once in suspension settles out only very slowly. In undisturbed water, clay particles settle out at a rate which does not exceed 30 cms. (about 1 foot) in 24 hours. The importance of this rate of settling in relation to silt-pitting schemes will be considered later.

(2) AGGREGATION OF PARTICLES.

It is possible to make these fine particles adhere together in crumbs which are more difficult to take up in suspension, and conversely more rapid in settling. The chief factor in producing this effect is humus which acts in two ways. Firstly, it acts as a cementing material binding individual particles, since its jelly-like nature allows it to form a thin coating round small mineral particles. Secondly, it brings about a complicated chemical effect usually spoken of as mutual flocculation. The result of this flocculation is that particles which are sustained in suspension by the water are precipitated and coalesce, the water thus losing its turbidity.

(3) WATER RETAINING CAPACITY.

Soils vary enormously in their capacity to hold water without water-logging, and in the rate of absorption of moisture. The conditions suitable for rapid erosion are those in which the top layer of soil rapidly becomes bathed in sufficient fluid to allow the particles to slip easily over each other. Anything which increases porosity and water-holding capacity and facilitates percolation will tend to prevent erosion. Again, humus plays an important part. The channels left by decaying organic matter provide both for intake of water and what is equally important in assuring absorption, outlet of air. Trapped air in the soil capillaries is one of the most formidable barriers to absorption. In addition, the moisture-holding capacity of soils is beneficially effected by organic matter. A sample of soil, from which organic matter and humus have been removed by natural or artificial agencies, attains at a lower moisture content than the original soil : the state at which free movement of soil particles takes place.

Applying the knowledge of these properties to the prevention of erosion, the task becomes a question of:—

(1) Checking the beating action of rain which churns up the surface soil.

(2) Maintenance of soil porosity which prevents the very severe loss from normal surface run-off.

(3) Fostering conditions which produce soil flocculation.

(4) Interposition of barriers to catch soil unavoidably lost, particularly such obstacles as will allow the tardily settling fine fractions to be recovered.

The rest of this memorandum will be devoted to the assessment, in this light, of some of the methods outlined in the Questionnaire as possible preventatives.

WEEDING.

The process of weeding as distinct from deeper cultivation loosens the surface soil to a degree sufficient to hasten the washing out of the fine fractions without effecting any marked amelioration in porosity. The surface water soon finds an impermeable layer and merely takes in its stride the loosened surface. On the occasion of the next weeding a further amount of soil is prepared for the erosive action of surface water. From this point of view clean weeding stands condemned.

With regard to the effect of clean weeding on leaching, this operation stands in the same category as any form of cultivation. Undisturbed soil, whether covered with vegetation or not, loses less nutrients than cultivated land, but losses on cultivated land are not all ascribable to leaching. Nitrogen is lost from cultivated soil where leaching is practically absent. On balance, the actual soil losses are more important than the leaching losses.

The disadvantages of clean weeding have to be weighed against possible advantages. Precise data are lacking. Of the two causes of crop deterioration, (a) competition of other plants, and (b) loss of soil, the first appears problematical, whilst the second is undoubted. In the long run erosion leads to a condition of soil poverty which even the lack of competition cannot counterbalance. Furthermore, there is no reason why, if clean weeding is abolished, the 'competing' crop should not be made actually beneficial in the end. The whole theory and practice of green manuring supports this view. With regard to covers of Oxalis, to quote a case in point, we have seen no evidence of competitive harm if growth through the plucking table is prevented, whilst its anti-erosive action is valuable. This does not imply that we regard Oxalis as being in the front rank of cover crops. The latter question is dealt with in a succeeding section.

HIGH SHADE AND GROUND COVER.

From general observation, high shade prevents two adverse conditions:—

(a) The churning of the surface soil by heavy rainfall.
(b) The rapid baking and caking of the top soil which reduces the permeability of the soil to water.

Inasmuch as high shade provides leaf-fall and mulch this beneficial effect is further enhanced. Generally, however, it does not prevent surface run-off. *It cannot be too strongly insisted that this latter is by far the most potent factor in producing erosion.* Even with high shade there will be great losses if the ground conditions are such that porosity is poor or opportunities for aggregation and flocculation of particles are absent.

The efficiency of ground cover is much greater, and it is to low cover that one must look for the greatest help in combating erosion. The mechanical resistance it offers to soil movement, the increased porosity derived from a much finer root system and the better distribution of organic matter entailed, operating on the principles outlined above, give ground cover a special value. As examples, may be mentioned the contrast in turbidity of drainage water on rubber estates planted with Vigna or left bare, and the still more striking contrast between bare tea and adjacent patna. The extra care in management which ground cover needs is amply repaid by the increased efficiency obtained.

CONTOUR HEDGING.

Hedges of *Tephrosia candida* or other material seem efficient in holding up soil and in giving general soil improvement. Much of the benefit of these hedges is lost if, when the material is growing old and losing leaf, they are uprooted or cut very low before a new and supplementary barrier has had time to grow. It is recommended that judicious alternation in sowing and cutting should be practised, so that the

Felsinger's Lock-and-Spill System of Bunded Drains.

Du Pré Moore's Contour Drain with Stone-terraced Bund.

slopes are never left devoid of soil-wash barriers. This system will be further referred to under silt-pits and new clearings.

SILT-PITTING.

From the point of view of anti-erosion methods, silt-pits constitute a second line of defence. It is more profitable to prevent erosion than to try and recover eroded soil. Silt-pit systems vary in type and efficiency, and the more important methods are dealt with in turn.

(1) SILT-PITS IN THE BOTTOM OF EXISTING DRAINS.

The usefulness of this system is subject to severe limitations. The velocity of the water flow in ordinary drains is such that only the coarser fractions of the soil are deposited. Whilst a continuous stream is running above these pits, the valuable fine fractions remain suspended and are carried away. This point is clearly shown both by the examination of the contents of such pits and by the considerations of particle settling velocity referred to above.

(2) THE FELSINGER SYSTEM.

This offers a real opportunity for the collection of eroded soil. The surface run-off is held up and the combined effects of settling and percolation cause all the fractions to be recovered. The efficiency should be measured not in terms of total solids that the bunded drains are capable of holding, but by the amount of water they can retain without overflowing the spills. As soon as rainfall is heavy enough, or continuous enough, to counterbalance temporarily percolation effects and bring the spills into operation, the efficiency is correspondingly decreased as far as fine fractions are concerned. When, on the other hand, the whole rainfall can be caught and percolated before another heavy downpour occurs, the system works admirably. In any event, the system is a very real and important contribution to the problem of soil erosion.

As an example of the capacity of Mr. Felsinger's system, the plan published in the *Tropical Agriculturist* for 1928 may be cited. With bunded drains 20 ft. apart the cubic contents will retain approximately an inch of rain before the spills operate.

The 20-in drain gauge at Rothamsted allows 50% of the rainfall to percolate, the rest being lost as surface run-off and evaporation.

Taking into consideration the lightness of precipitation and the condition of English soil, this is a liberal estimate of percolation if applied to Ceylon conditions, where slope, porosity, and rate of precipitation are not so favourable for absorption. Taking this figure, 2 inches of rain would fill and temporarily put out of action the system.

On Primrose Hill, Mr. Felsinger has enlarged and strengthened the system by a series of staggered silt-pits between the drains. Not only does this increase the capacity, but it arrests water before its velocity has been so accelerated that it produces a scouring effect. In addition the upper sides of the pits have Tephrosia hedges, the leaf-fall of which into the pits maintains the porosity of the deposited soil. The periodical clearing of the drains and the redigging of silt-pits, which Mr. Felsinger rightly locates anew, is fundamental to the success of the scheme.

(3) THE DU PRÉ MOORE SYSTEM.

This system also appears to work admirably on ground rather different from that suitable to the previous system. Since no spills are ordinarily provided, it suits medium rainfalls well distributed. Where the slope is moderate, a bund formed of the earth removed from the contour drain placed above it acts as a barrier for soil wash, all the water collecting above the drain in the fold of the bund having to percolate through into the contour drain. On the question of bunds above or below drains, Mr. du Pré Moore's system appears to have the advantage. The presence of a drain, which by reason of the bund above is at first relatively empty, (only becoming filled by percolation) provides an air outlet for trapped air and materially helps the percolation of any temporarily standing water in the fold. With bunds below, and drains consequently filled, this advantage is absent.

Further, the bund above minimises slope of land; the bund below accentuates it. A Tephrosia hedge would help to consolidate the bund of newly-turned earth and prevent breaching under severe conditions. In difficult circumstances, a stone terrace between the bund wall and the drain is sometimes necessary.

(3) THE DENHAM TILL SYSTEM.

As far as our knowledge goes this system is also of great usefulness in rubber. We foresee difficulties with tea.

These three systems have a further great advantage which, apart from prevention of soil wash, undoubtedly contributes to their usefulness as practical planting measures. They all retain the water on the land instead of conducting it away. Soil samples taken from Mr. Felsinger's drains on November 4th after the drought of October and no recent precipitation, gave an average moisture content of 17·2%. Throughout the estate there was abundant evidence of good moisture relations. The question arises as to whether this retention of moisture can be overdone. Our impression is that on slopes such as merit the employment of soil erosion measures, the natural seepage which takes place is sufficient to maintain something like

Du Pré Moore's Contour Drains. The heavy shadow is cast by the bund above each drain.

PLATE II.

optimum water relationships without fear of water-logging. Furthermore, from the point of view of crop growth, the retention and percolation of the water brings great benefit since the rainwater contains dissolved oxygen which renovates the soil atmosphere. It should be remembered that this distribution of dissolved oxygen constitutes one of the major methods of securing soil aeration, particularly, for subsoils. Provided, therefore, that the seepage is adequate, the retention, temporarily, of the increased bulk of water is a very real asset both from consideration of moisture and aeration. Some increase in leaching may be expected which can be counteracted by other methods of soil amelioration.

CONTOUR PLANTING.

Whilst contour planting will undoubtedly tend to prevent acceleration of running water, it cannot be regarded as contributing largely to the prevention of soil erosion since the barrier provided by the stem is not great. In connection with the systems of silt-pitting and draining discussed here, it has the advantage of making those systems more simple and effective. For example, the staggered silt-pits referred to on Primrose Hill would be difficult to accommodate on land planted vertically up and down. A similar break in water channels can be effected by triangular planting, a method which also produces a very satisfactory articulation of the bush frames, and consequently a good cover in the mature bush.

NEW CLEARINGS.

The treatment of new clearings is undoubtedly unsatisfactory, but it is realised that the opening of land presents difficult problems. From the start some such system as the Felsinger and du Pré Moore systems should be adopted for drainage, and at the same time soil amelioration methods should be carried out both before and after planting.

We are under the impression that the very fine cover of 3-year-old tea exhibited by Mr. du Pré Moore is largely due to his drainage system coupled with the fact that he does not burn his patna. The land is well holed and forked for seed at stake. The maana grass rots, and other tuberous grasses are hand picked. Though this is at first costly, it represents a great conservation of organic matter which helps both nutrition and anti-erosion methods.

On jungle the difficulties are still greater, but we recommend that where possible a temporary cover be sown immediately on clearing. We have seen *Vigna sinensis* (Cowpea) growing luxuriously, and note the ease with which it can be removed when necessary. Furthermore, it does not interfere with holing operations. We would urge that some such crop, supplemented by contour hedges, be grown and dug in up to the time when they would endanger young seedlings or stumps. In other words, that every effort be taken to preserve a soil of good tilth and porosity from the very start.

PERMANENCY OF EXISTING METHODS.

If by permanency and non-permanency of existing methods is implied the possibility or necessity of radically altering systems of planting and replanting, it does not appear to us that any sudden change is feasible. New tea can be planted with attention to improved methods, but old tea is another matter. Something in the nature of recutting drains on improved lines might be done, but we refrain from trespassing in a sphere where our experience is necessarily limited.

LEGISLATION.

The same difficulty arises here, that of dealing with existing plantations. Legislation would almost necessarily involve a criterion of neglect, and with the very varied situations and local problems, the assessment of neglect would be a very difficult, not to say invidious, task. Efforts for prevention of soil erosion successful in one locality might prove ineffective in another.

Apart from stipulating enlightened drainage systems when new leases are granted, it is difficult to see any effective method of legislation. The problem is really one of education, and in this matter the co-operation of the Tea Research Institute in experiment and propaganda will be most whole-heartedly given.

We cannot, at the moment, table schemes for checking soil erosion on St. Coombs, but we can give the assurance that these will be a matter of early discussion, and that they will take the form indicated by our visits to existing systems, and by the fundamental soil properties here outlined.

(Signed) ROLAND V. NORRIS,
Director.

T. EDEN
Agricultural Chemist.

SUPPLEMENTARY MEMORANDUM ON SOIL EROSION.

EVIDENCE SUBMITTED TO THE SOIL EROSION COMMITTEE BY THE TEA RESEARCH INSTITUTE.

The publication, in the form of a lecture to the Dimbula Planters' Association by the Director of the Institute, of the evidence on Soil Erosion submitted by the Institute to the Soil Erosion Committee, has led, as was hoped, to some discussion of that evidence, and to a certain amount of criticism. In order to increase the usefulness of the Institute's Memorandum it is thought advisable to extend our evidence so as to deal with the specific points that have been raised. These may be briefly set out as follows:—

(1) The calculated capacity of the Felsinger drains is held to have been greatly over-estimated. A figure of 0·35 in. of rain is suggested in place of our approximate figure of 1 in.

(2) Exception is taken to the statement that the Felsinger system, along with others discussed, *prevents* soil erosion.

(3) It is objected that the recommendation of a relatively clean weeded system, such as the Felsinger system, is at variance with that part of the evidence relating to the disadvantages of clean weeding and the benefit of cover crops.

(4) The opinion has been expressed that the clearance above the bunds of the Felsinger drains is so small (about 3 in.) that in time of heavy rainfall the spills will not be able to deliver the volume of water likely to accumulate, with a consequent risk of overflow occurring over the side of the drain, and the production of a sheet of running water descending to the drain below.

We shall take up these points *seriatim*:—

(1) We append the basis of our calculations for the capacity of the Felsinger drains which will confirm our approximate figure of 1 in. In order to dissipate any doubts on the subject, we would point out that the contrary figure of 0·35 in. is based upon a misreading of the original article in the *Tropical Agriculturist* for 1928 (page 214) from which the following quotation is taken:—

> " If silt accumulates in each pocket to a height ranging from 1 to 11 inches, or an *average of 6 inches* or ½ a foot, and the width of the channel is 1½ ft., each pocket or drain will contain 10½ by 1½ by ½ ft., or about 8 cubic feet of silt. This works out at about 1,280 cubic feet to the acre."

The italics are ours. We stress in our evidence that the "efficiency should be measured not in terms of total solids that the bunded drains are capable of holding, but by the amount of water they can

retain without overflowing the spills." The height of the drains from the bottom to spill level is however not 6 in. but 15 in. which accounts for the greater part of the discrepancy between the two figures. The rest is due to the fact that by a rather more economical use of the land we fitted 175 drain pits to the acre as against 160 in the original article. Our figures accordingly stand uncorrected.

We may mention that our argument in this section aimed at showing the limitations of the Felsinger system under heavy rain, and in order to make our point justly we took the conditions most favourable to the Felsinger system, *i.e.*, the system at its maximum capacity. The system decreases in efficiency as the pits silt up. We would again refer to our evidence—"The periodical clearing of the drains and redigging of silt-pits . . . is fundamental to the success of the scheme."

(2) From a perusal of our evidence, it will be seen that we attach considerable importance to the effect of surface run-off. The answer to the question as to whether the Felsinger system *prevents* erosion in contradistinction to collecting eroded soil is found in our description of the system. Referring to the staggered silt-pit formation, which is an integral part of the system, we say—"it arrests water before its velocity has been so accelerated that it produces a scouring effect." The term is relative, but it cannot seriously be maintained that scouring is greater under these circumstances than would be experienced on ordinarily drained land.

(3) Under this section it is only necessary to say that to quote our advocacy of good systems of drainage as contradictory to our recommendation of cover instead of being complementary to it, is to make use of a false antithesis, and to misconstrue certain passages of the evidence out of the context of the whole document.

(4) The fear that a lateral overflow will occur in the Felsinger system can be tested by calculating the delivery of the spills. The velocity of the stream and hence its delivery is affected by the gradient, the area of contact between the water and its containing wall, and by the frictional resistance that containing wall offers. In calculating the wetted perimeter, we have assumed a maximum area, and we have also used the maximal frictional constant for rough earth channels, in order to be on the safe side. We have used Chezy's formula for flow, and Bazin's formula for coefficient of discharge, as being applicable to small channels, and we find that the delivery of rainfall from 1 acre of the Felsinger system would have to exceed 11·4 inches per hour before the drains overflow laterally. The fear is therefore ungrounded.

APPENDIX.

The capacity of the Felsinger bunded drains.

	Dimensions quoted in original article		Dimensions used by T. R. I.
Length of lock	10½ ft.	...	10½ ft.
Length of bund	1½ ft.	...	1½ ft.
Bund at main drain	2 to 3 ft.	...	2 ft.
Width of drain	1½ ft.	...	1½ ft.
Height of bund	14 to 15½ in.	...	15 in.
Clearance above bund	2½ to 4 in.	...	3 in.
Distance apart of drains	15 to 25 ft.	...	20 ft.
Main drain	3 ft.	...	3 ft.

An area holding 50 pockets, 5 on each side of the main drain, occupies ·285 of an acre according to the following dimensions:—

Locks	$10 \times 10 \cdot 5$	...	105·0
Bunds	$8 \times 1 \cdot 5 + 2 \times 2$	...	16·0
Main drain		...	3·0
			124·0

Depth of 5 drain series $5 \times 20 = 100$ ft.

Area 1,240 sq. ft. = ·285 acres.

Volume of each lock = $10 \cdot 5 \times 1 \cdot 5 \times 1 \cdot 25$ = 19·7

20 cubic feet is taken as an approximation.

The total capacity for ·285 acres is therefore 1,000 cub. ft.

Reduced to acres the cubic capacity is 3,510 cub. ft.

1 in. rain = 3,630 cub. ft.

The capacity in inches of rainfall is therefore 0·97 in.

(Signed) ROLAND V. NORRIS,
Director.

T. EDEN,
Agricultural Chemist.

SOIL EROSION.

THE MEMORANDUM OF THE IMPERIAL BUREAU OF SOIL SCIENCE.

(REVIEW)

The recent Memorandum of the Imperial Soil Bureau* summarises work and inquiries into soil erosion in India, Ceylon, South Africa, New Zealand, Nyasaland, and the United States of America. For the purposes of this review only those aspects of the problem of combating the damage which are relevant to tea cultivation are reproduced. At the same time comparisons will be made with the evidence given by the Tea Research Institute before the Ceylon Committee.

WATER RETENTION.

The memorandum draws attention to the fact that even though soil erosion may appear to be a very slow process, it is in fact very rapid in comparison with the reverse process of building up soil in an agricultural sense. Virgin soils opened for cultivation are often the product of many centuries of soil-building through the agencies of forest and grass-land. Coupled with the actual loss of soil is the loss of water supply. In the Union of South Africa, evidence was given of the marked decrease in underground water, and in Nyasaland the gradual deepening of gullies due to erosion caused a lowering of the water table with consequent harmful effects upon the moisture of the surface layers of soil upon which crops under cultivation depend during periods of drought. These findings confirm the recommendations stressed in our evidence that, wherever possible, water should be kept on the land by increasing the soil permeability and by such devices as bunds, contour and bunded drains.

TRANSPORT OF FINE EARTH.

Interesting figures are quoted for the sizes of particles that can be transported in streams of running water such as occur in normal drains. Our evidence emphasized the fact that unless the flow in drains was checked, the ordinary silt-pit was relatively inefficient as a collector of the valuable fine particles. The memorandum gives the following figures for the transportation of particles of various kinds:—

Silt requires a velocity of	0·25 ft.	per second.
Loam requires a velocity of	0·50 ,,	,,
Sand requires a velocity of	1·00 ,,	,,
Gravel requires a velocity of	2·00 ,,	,,
1 in. Pebbles require a velocity of	3·50 ,,	,,
Broken Stone requires a velocity of	4·00 ,,	,,
Chalk and Soft Shale require a velocity of	5·00 ,,	,,

* Imperial Bureau of Soil Science. Technical Communication No. 5. Soil Erosion. December, 1929.

In the supplementary evidence of the Institute reference will be found to the quantity of water the drains in the Felsinger system can deliver. From a modification of the same formulae, the velocity of water in a 1 in 30 open drain can be derived. The value for a 3 in. flow amounts to 0·88 ft. per second. It is therefore evident that silt and loam are frequently lost in drains where the silt-pitting system is such that no positive barrier is imposed to diminish the velocity of the running stream. The memorandum points out that since, as demonstrated above, the velocity of run-off is the all important factor in erosion, short heavy downpours are most significant as erosive agents, and total rainfall is a very inadequate measure of erosive power.

SLOPE OF LAND.

The importance of slope of land in helping erosion is obvious, and to give this a quantitative confirmation the memorandum quotes a three-year experiment in Missouri where starting from a gradient of 1 in 27, each 1% increase in gradient resulted in an increase in erosion of 25%. Such figures throw into high relief the necessity of terracing and bunding *above* drains, whereby the effective slope is substantially decreased.

NATURE OF SOIL.

The differences that exist in susceptibility to erosion in different soils have received very little attention, but our evidence is in keeping with the Bureau's memorandum in viewing permeability as important. Speaking of experiments with various soils, the memorandum says: "It seems likely that these differences are due to permeability; the plastic clays become water-logged almost at once, the surface run-off is therefore high and the transporting power of the water very great."

EFFECT OF VEGETATION AND AGRICULTURAL SYSTEMS.

Passing to the influence of various systems of cultivation and green manuring, the American work provides interesting data. An eroded and non-eroded soil of the same type were subjected to pot-culture cropping tests with the following results:—

	Eroded.	Non-Eroded.
Water-holding capacity ...	46·8 %	... 67·2 %
Nitrogen content ...	0·16%	... 0·49 %
Humus ...	6·60%	... 14·60%
Dry weight of wheat produced ...	5·5 lbs.	... 12·1 lbs.
Water requirement per lb. dry matter produced ...	472	... 343

No more striking evidence of the fundamental differences between eroded and non-eroded soil could be imagined. The eroded soil is low in humus, water-holding capacity, and in nitrogen. It produces an inferior crop and requires more water per unit of crop to do so, whilst being at a disadvantage in its retentive power for moisture.

Further evidence is also presented on the loss of soil nutrients which the loss of soil involves. Of particular interest in Ceylon are experiments at Missouri showing nutrient losses on soils where the

treatments included clean weeding, continuous cropping with the same crop, a rotation which provided for a cover crop of clover, and permanent cover.

	Amounts removed in one year in lbs. per acre.		
	Nitrogen	Phosphorus	Calcium.
No crop, clean weeding ...	98·88	47·47	379·38
Continuous Wheat ...	92·58	10·83	75·99
Rotation Maize, Wheat, Clover	5·94	2·22	41·47
Continuous Blue Grass sod ...	0·55	0·09	0·64

The effect of clean weeding is to remove more nitrogen, phosphorus, and calcium in the absence of any crop than is removed by wheat, even taking into consideration the demands of the crop itself. Losses grow progressively smaller, as the cover becomes more efficient.

In South Africa in the evidence of the Drought Commission, erosion is shown to cause the loss of half or more of the nitrogen, potash, and phosphorus in a number of cases.

PREVENTATIVE MEASURES.

The preventative measures advocated by the U.S.A. Bureau of Soils may be quoted in full. They correspond in detail to those of our own evidence.

(a) *Treatment of the soil*:—this may include keeping texture in good condition by deep tillage so that its range of moisture capacity is large.

(b) *Treatment of cover*:—this has for its objects:—

(1) Protection by shielding from direct rain beat; dissipating heavy rains into small particles which easily soak in; accumulating debris to form mulch; reducing evaporation.

(2) Promotion of soil plant circulation by catching and retaining water, retarding run-off, keeping the soil moist and open, and allowing root taps (*i.e.*, tips) to ramify near the surface, and

(3) Enrichment of the soil by amassing mulch, facilitating root development, decomposing inorganic substances by carbonic acid and conserving humus.

(c) *Treatment of slopes*:—this may involve cultivation along contours, terracing, vineyarding, building retaining walls, and providing transverse belts of woodlands which widen as the slope steepens and narrow as it flattens."

The reference to evaporation reduction corresponds to the prevention of drying and caking of soil mentioned in our evidence as detrimental to the permeability of the surface soil.

The memorandum concludes with a detailed discussion of terracing in a form not suitable for tea, and refers in brief to the Felsinger system of bunded drains.

T. EDEN,

GREEN MANURING AND SOIL CONSERVATION.*

T. EDEN,

Ceylon is passing through a stage of agricultural development which confronts every country where intensive agricultural enterprise is, relatively speaking, in its infancy, the stage at which the primary concern is less with soil exploitation than with soil conservation.

No matter where we turn, in long established systems of agriculture we shall find that provision for soil conservation and recuperation is part of the accepted routine. The Mosaic law, for instance, prescribed one year in seven for a field to be left fallow, and in Mediæval England one field in three was yearly left without crop. More recently in the wheat growing prairie lands of North America the continuous growth of grain and the extravagant waste of burnt straw, which characterised early efforts, have been replaced by logical systems of crop rotation. These examples suffice to illustrate the methods which sheer necessity has forced on the agriculturist for the preservation of his soil as a medium for plant growth.

The use of green manures is an ancient practice for the furtherance of this end which fell into disuse and has been revived during the last century. I propose to discuss the principles and possibilities of this feature of cultivation as it affects tea growing in Ceylon.

For convenience I shall deal with the plant as it grows first, then with the effect of its incorporation in the ground, reserving till the last a short discussion of general principles of management.

EFFECT OF GREEN MANURES WHILE GROWING.

Whilst growing, the green manure acts as a soil conserver in two ways. It offers protection from the direct impact of rain on the soil, and it makes for ease in soil drainage. The first point needs no elaboration; the second is perhaps not so obvious. The greatest losses of soil are brought about not by the beating action of the rain, but by the fact that the soil cannot normally absorb water at the rate at which it is precipitated. Consequently, there is a surface run-off of serious dimensions which carries with it surface soil, particularly the finer fractions. Nothing short of the reduction of surface run-off is going to make a striking impression on soil conservation, and anything which helps this reduction is a valuable factor. An increased porosity is a fundamental necessity. Consider what happens as the rain falls. At first a rapid uptake occurs owing to capillary forces at work in the

* The following article reproduces that portion of a lecture delivered before the Pussellawa Planters' Association on October 23rd, 1929, which dealt with green manuring in relationship to soil erosion. The remaining portion describing the effect of green manures on the nutritional cycle in the soil followed the lines of the article in this Journal, 1929, Vol. 2, page 96.

fine channels between the soil particles. This process receives a check as soon as these small channels are filled, because for free movement not only must the rain enter but air also must escape. If absorption is to continue rapidly, there must be some other channels besides capillaries. Consequently, it is to the larger fissures that one looks for the escape of air. Such channels are readily provided by the decay of rootlets and the excavations produced by the growths of new ones. In this way the growing green manure helps to keep the soil porous. Another effect that is beneficial is the prevention of rapid drying of the soil surface by baking sun after rain. Nothing so contributes to impermeability as that does.

These two effects immediately raise the question of ground cover *versus* high shade. Ground cover, regarded as a growing crop, has certain distinct advantages over high shade. The latter, efficient as it is in lessening the impact of rain, contributes little to the diminution of surface run-off, for the underlying ground is bare. On the other hand, ground cover, besides affording protection against beating rain, interposes a useful barrier against soil movement, and because its root system is finer and more thoroughly ramified, it maintains the soil porosity at a higher degree than high shade can hope to do. The aversion to its use, apart from a scarcity of acceptable species, appears to be the result of fear that competition or toxic properties will interfere with the growth of tea. The toxic properties of plants have never been generally confirmed by experiment. There is, of course, bound to be competition for air, light and moisture, but not necessarily to a greater degree than in the case of shade. Inasmuch as ground cover is shallow rooting, and practises not a directly competing but a complementary economy in root action, it may be said to have the advantage over high shade. Anything, however, in the nature of a turf-like or peaty mat, such as may be formed on the surface, is to be avoided. This will be discussed under cultivation. In assessing the evidence for and against a cover crop, due attention has not always been paid to the fact that, even if it offers to tea sufficient competition to produce a temporary decline in yield, its ultimate effect is to conserve both soil and soil fertility. On the other hand, a bare soil subjected to erosion is fated to reach a dead level of unproductiveness. The Peradeniya work with Indigofera has not as yet detected even the initial set-back which might be expected.

EFFECT OF GREEN MANURES IN THE SOIL.

All the benefits which a green manure crop confers on the soil whilst growing are enhanced when the green stuff is incorporated in the soil. The decay of large quantities of green stuff, acting on the self-same principles as the decay in roots, continually makes and remakes those very channels which help drainage. Moreover, as humus is formed the fine particles of soil are coated by a jelly-like film

which cements them together. Instead therefore of a compact mass there is produced a more granular structure of soil crumbs. Nor does the effect stop at a simple amelioration of drainage and porosity.

Soil erosion can only occur when the particles of top soil are bathed in sufficient fluid to allow them to slip easily over each other. If we take soil devoid of organic matter, we find that this "flowing point" is reached at a much lower moisture content than soil well provided with humus, so that in this way the adverse effect is postponed.

Finally, there is a complicated chemical effect taking place. The ease with which fine soil particles remain suspended in water is greatly influenced by the presence of other substances. Some of these help to sustain the suspension, and are said to deflocculate the soil; others have the opposite effect and cause a rapid aggregation of fine particles which then sink, leaving the liquid clear. Conversely, the first class of substances makes it easy for the fine particles to be taken up; the second relatively more difficult. Humus belongs to the second class in that particles of humus and clay mutually flocculate each other under certain circumstances, and thus loss of fine soil is hindered. It must be a sight common to your experience to see the difference in turbidity between, say, the discharge of heavy rainfall from bare tea land, and adjoining patna or scrub jungle. To sum up then, in the soil the green manure counters erosion by increasing porosity, increasing the water-holding capacity of soil, and by encouraging the aggregation of the fine particles.

GENERAL PRINCIPLES OF CULTIVATION.

There remains the consideration of how the effects spoken of can best be brought about. In the first place, is it better to allow loppings to accumulate as mulch, or to bury them, and if so, fresh or dry ? A mulch has certain beneficial properties peculiar to itself, the foremost of which is its capacity for reducing loss of soil moisture from the ground, but there are disadvantages too. A mulch to be effective must be general. Lesser quantities of organic matter left on the top are easily carried off by the surface rain and wind, and only serve to choke drains. The organic matter has little or no opportunity of exerting all those beneficent properties on the soil, which have been detailed. Furthermore there is a definite loss in manurial value. The alternate drying and thorough wetting of the leaf provides just the right conditions for loss of nitrogen in another form, *i.e.*, as gaseous nitrogen discharged into the air. The work done in the Department of Agriculture on tea prunings, which demonstrates this, applies equally to green manures. Despite labour and cost difficulties, forking in is advisable. It gives the green stuff an anchorage and uses it to the full advantage. Where this is impossible, a system of thatching the rows with leaves downwards is advisable as a useful

preventative of both actual loss of organic matter and potential loss of nutritive value. There does not appear to be much difference between forking in the dry leaves beaten off the branches and forking in green, provided that the operation is not long delayed.

The policy of forking in with artificials is a sound one. Mixtures containing readily available nitrogen and some lime, such as are constantly used, aid the breaking down of the green stuff, but where this involves a sacrifice of convenience it is not vital.

Cover crops are not so general in tea as to provide much data as yet on questions of cultivation. I hope that experiments on this subject will form part of our future work at St. Coombs. From all points of view it seems to me that periodical cultivation and digging in will have to be practised not only to check any smothering tendencies that may be manifest, but in order to derive the full benefit from the accumulated organic matter, and to promote new and healthy growth. Moreover, green manure crops need cultivation and aeration as much as any other crop. Presuming that they are leguminous, they have a special need for soil aeration. In saying that they fix atmospheric nitrogen, it must be remembered that it is the soil atmosphere that is meant. Unlike tea, green manures offer possibilities for rotation with all its attendant advantages. A cover, mixed both in matter of species and of age, is preferable to a uniform cover, and the total crop is likely to be larger. Here again it is a question of different species practising rather different economies in the matter of nutrition and light.

One hears of the difficulty of establishing cover crops. It is inadvisable to dogmatise, but there are two suggestions which may be worth considering. Where altitude is the difficulty, it is worth while acclimatising the tree by advancing up the slope gradually, and not supplying from altitudes very much lower. A great measure of success has been experienced by treating dadaps in this way. There is also the possibility that the "something lacking" in the soil is not chemical but microbial. The leguminous crops do not produce nodules on their roots from sheer altruism; without them they themselves languish. But the production of nodules depends upon the specific bacterium being present in the soil in the first place. Where the crop has been grown for some time, the organism is already there to perform its useful function on new plants, but it is by no means ubiquitous. A basket of earth from land already carrying the crop put in each hole is a rough and ready method of inoculation, but it is usually satisfactory. These are some of the many points which present themselves for consideration. In covering ground rapidly, I have tried rather to bring up points which merit discussion than to deal in matters of detail.

HELOPELTIS IN CEYLON.

S. STUART LIGHT

The fact that this very serious pest of tea, causing so much loss of crop in India, Java and other tea-growing countries, actually attacks tea in Ceylon may be a cause for alarm to those who are not aware of the insect's true status in this country. That no account of Helopeltis as a pest of tea in Ceylon has been published for many years has been a further inducement to the writing of this article.

Helopeltis antonii was described by Signoret, a French entomologist from Ceylon in 1858; the food plant on which it was found is not mentioned in Signoret's account, but Green (*Insect Pests of the Tea Plant*, 1890, 71-8) thought that it was probably cacao. The first definite record on tea was in the Kelani Valley, near Yatiyantota, in 1883. The pest became abundant in this district in 1892, leading to a suggestion for concerted action at a meeting of the Kelani Valley Planters' Association in 1893. In 1890 much damage was reported in Kalutara; in 1891 Helopeltis was observed in the Balangoda district, and infestation of estates in Morawak Korale was recorded in 1889. Galboda, Nawalapitiya, Rakwana and Galle districts have also been visited by this pest.

Recent enquiries have elicited the following general facts with regard to the present distribution of Helopeltis. Attacks of some severity occur annually in the Morawak Korale district, every estate probably being affected to a greater or less extent. Regular occurrence is reported in Rakwana, but the outbreaks are probably less serious. From information supplied by a planter of many years' experience in this district, I gather that Helopeltis was much in evidence during 1921-26, less noticeable in 1927 and only slight in 1928. These two districts are evidently the main areas of infestation at the present time. Periodical attacks, often, however, of very slight intensity, occur in the Kelani Valley, Kalutara and Galle and possibly in Galboda. It will thus be seen that Helopeltis has become reduced considerably in recent years, and is now no longer a pest of importance, except in the two principal districts mentioned above.

The adult bug is about a quarter of an inch long, black, with reddish thorax (forepart of the body), this region being surmounted by a characteristic knobbled spine, nicknamed the "drumstick." Wings are functional in the adult stage, the younger forms, or nymphs as they are called, possessing only the rudiments of wings. The eggs are laid singly or in groups of two or three, embedded in the tissues of the young stems, generally above the fish leaf; a pair of hair-like processes alone projects from the stem.

The insects feed principally at night. As soon as the sun rises they apparently disappear from the bushes. It is curious to see how in a field showing evidence of severe injury not more than a few hours old, shortly after the heat of the sun strikes the bushes hardly a bug is visible, except for an occasional adult flying from bush to bush. The natural supposition is that the bugs have retreated to jungle or other wild growth in the neighbourhood, but this is evidently not usually the case. Green pointed out that this theory had never been proved and was extremely doubtful. I myself have examined jungle, scrub and marsh land bordering on attacked fields two or three hours after sunrise, and have not found a trace of the bugs. Actually, in the case of the nymphs at any rate, the insects conceal themselves low down in the centre of the bush. To quote Green again—"A minute examination of the centre of the bush produces no better result, though it is almost certain that they are somewhere there." Smee (*Nyasaland Prot. Dept. Agric. Bulletin No. 4, Entomological Series*, 1929) also observes this habit of lying concealed in the bush in connection with *Helopeltis bergrothi* in Nyasaland. What adds to the difficulty of detection is that shaking or beating the bush does little towards dislodging the nymphs.

The season most favourable to Helopeltis is the period between the S. W. and the N. E. monsoons, *i.e.*, July to September, dry, windy weather at that time being particularly suitable to its development. The N. E. monsoon causes a decline in the numbers of the insect, and a revival occurs in February-March, which, generally speaking, is less severe since Helopeltis does not thrive in a severe or prolonged drought.

The attack of Helopeltis is particularly serious in that the insect feeds only on the young shoots. By means of its long proboscis, or "rostrum," it sucks out the cell sap from the leaf and, to a lesser extent, from the stems, leaving a series of spots, each marking the place of a feeding puncture. In the leaves the tissue of the spot turns brown and dries up to a thin transparent film. The spots, when numerous, run into one another, causing a larger discoloured area which often cracks, forming a hole in the leaf. This damage to the leaves results in their crumpling up, the flush often turning quite black. A dotting of the leaves with fine spots, much smaller than those produced by the adults, indicates damage by immature bugs.

Injury, very similar to that due to Helopeltis, is caused by a variety of bugs that are occasionally found feeding on tea, notably, species of *Disphinctus*, and possibly also *Callicratides rama* (see later), Helopeltis injury is frequently confused with the Cercosporella leaf disease, but they differ in several details. Helopeltis causes rather angular spots which are transparent in the centre; Cercosporella spots are round and opaque.

In badly attacked fields it is usual to see nearly every bush affected to some extent. Thus, in severe outbreaks, when each bud as it appears is immediately punctured and killed, the effect on the bushes may be readily imagined; flushing ceases entirely and the yield is affected correspondingly. In Morawak Korale, even at the present time, the total yield from infested fields may drop by over 50 per cent. during the worst periods.

This state of affairs may continue for as long as a month, and the loss of vitality to the bush is evident in the after effect. Badly attacked bushes are said not to recover completely until pruning; those lightly attacked may recover in 4-6 weeks. On very old tea of poor quality the effect is apparently cumulative, so that their condition becomes gradually worse and worse, leading to their eventual removal from the soil. The bushes are usually not attacked until nine months to a year after pruning. Opinion is universal that only small-leaved, low jât tea is severely attacked. Bushes of good jât are not injured sufficiently to affect the crop to an appreciable extent. Green asserted that pure Assam indigenous tea was practically immune and, in the case of hybrids, the greater the proportion of China strain the more liable were the bushes to attack. Another quotation from Green (*Royal Botanic Gardens Circular, Ser. I*, No. 21, 1901) furnishes a striking example of the discrimination shown by Helopeltis. He says, referring to an estate in Kalutara—"Two adjoining blocks, without any intervening boundary, were planted; the one with indigenous Assam plants, the other with a low jât hybrid. It was possible to walk up between the two adjoining rows and see the tea on one side quite healthy, while every bush on the other hand was badly blighted."

CONTROL MEASURES.

Although parasites of some importance in the form of wasps and Myrinthid worms, as described from Java and India, may attack Helopeltis in this country, no record of such a discovery exists. It is probable, therefore, that parasites are not a factor of importance in controlling Helopeltis. Birds do not readily attack the bugs, possibly on account of some repugnant fluid that the latter are capable of excreting, a common feature in this order of insects.

Since windy weather favours attacks, the planting of wind belts would appear to be a sound proceeding. But this must be done with caution, for it has been found in Java that wind belts sometimes cause more harm than good by harbouring the insects that are driven into them, thus acting as a source of infection to the tea.

The encouragement of shade trees cannot be recommended as a control measure, although some planters are of the opinion that light shade is beneficial. It has been said that heavy shade is worse than useless and definitely encourages the insects. I have been informed

by one planter in Morawak Korale that many years ago the field with the finest cover was the most badly attacked on the estate A similar statement was made by Peal, in Assam, who wrote that attacks were worst under large trees and on the edges of forest land.

Pruning, as already suggested, has the effect of checking the insect for nine to twelve months, so that in very severe cases where bushes have been so affected as to cease yielding for protracted periods, pruning must be resorted to. In an eighteen months pruning cycle this procedure would probably interfere little with the normal routine, but in a longer cycle pruning might have to be carried out considerably earlier than usual and, if this were repeated often, the bushes would certainly suffer. I do not think that special emphasis need be laid on the burning of prunings. In any case careful burying would probably serve as well, but neither process appears to me to be worth while applying expressly for the purpose of control.

Insects of the type of Helopeltis do not readily come to light, thus the use of bonfires for this purpose, which was at one time considered, may be rejected as useless.

On account of the fact that the eggs are laid in the stems of the flush and the insects feed on the young leaves only, hard and repeated plucking has been suggested as a likely measure to lessen the trouble. Some planters who tried this in Green's time stated that it brought no relief; one even declaring that most damage was caused where hard plucking had been carried out. Green, writing in favour of the method, argued that this adverse effect might be apparent at first, since the adult bugs would probably be driven to attack the buds as they appeared, but that when this initial generation had died out, few young ones would be left, since nearly all the eggs would have been removed with the young stems. Green's argument certainly seems reasonable. My advice, therefore, is to give hard plucking a fair trial, experimentally.

A method that has been commonly practised in the past and which is still generally followed is that of hand collection. When Helopeltis first developed into a pest of importance coolies were often paid so much per hundred, for insects captured. Hand collection is still recommended, to be stimulated, where necessary, by the institution of a scale of payment. But in very severe attacks it is apparent that collection has little effect. Collection might be assisted by the use of sticky screens placed beneath the bushes to catch the insects shaken off; this is a matter for experiment. For ease in handling, the screens could take the shape of a shallow bag atttached to a hemispherical wooden or bamboo frame, provided with a wooden handle. This apparatus might also be used for catching the flying adults.

It is probable that more can be done by cultivation and manuring than by any other method of control. The fact that only low jât tea and bushes in poor condition are attacked severely, and the testimony of planters who have tried manuring for Helopeltis, support this idea. It is believed that the increased use of manures and general cultivation have been largely responsible for the reduction of the pest in the Kelani Valley and elsewhere. But it must be realised that tea 40-50 years old, which is often nearly "played out," cannot be expected to show a rapid response to cultivation. In many cases, where such tea occurs, unlimited cultivation would probably fail to produce immunity from insect attack. Planters should experiment in varying the constituents of manurial mixtures, carefully noting and following up the most favourable combinations.

CALLICRATIDES RAMA, KIRBY.

This green Capsid bug is frequently found associated with Helopeltis, often in considerable numbers. In the first consignment of Helopeltis that was sent to me for examination, in 1928, fully 30-40 per cent. of the insects were Callicratides, and in Green's records occurs a case where the latter were five times as abundant as the Helopeltis! This species is found commonly on tea in various districts, single specimens usually being taken; I have seen it in some abundance in the Balangoda district.

There is, however, much uncertainty about the true significance of Callicratides. Green has no records of definte injury, and the present Government Entomologist (Dr. Hutson) tells me that when he has confined specimens of Callicratides with tea shoots, no spotting of the leaves has been observed, although there has been appreciable injury to the stems. Smee, (1929, *loc. cit.*) who adds a note on this species to his paper on Helopeltis, states that in captivity the insects did not feed on tea, but were found to feed readily on a species of bean grown as a cover crop for the tea. The life history, after hatching from the egg, lasted from 14-16 days. The adult Callicratides is about one-third of an inch long, green, with hyaline (glassy) wings and the wing veins are very pronounced. The eggs are similar to those of Helopeltis and are also laid in the young stems.

SUMMARY.

1. Helopeltis, although an important pest of tea some 30 years ago in the Kelani Valley and other districts, has since been so reduced that only two districts are still affected to an extent that calls for attention.
2. Outbreaks are most severe in the season July-September, minor attacks occurring in December-February.
3. The bushes are attacked usually at nine months to one year from pruning.
4. During severe attacks the bushes cease to flush and for several weeks the yield may be reduced by 50 per cent. or more.
5. Serious defoliation is confined to bushes of low jât or those in very poor condition.
6. Shade is of little benefit. The insects do not come to light. The disposal of prunings cannot be considered a measure of control worthy of attention.
7. Hard plucking should be given a trial on an experimental scale.
8. Hand collection as a routine measure is recommended with the added suggestion of payment during severe periods. The use of sticky screens should be tried.
9. The application of manures and general cultivation will probably provide the greatest check to this pest with a likelihood of permanent results.

In conclusion, I wish to express my unqualified thanks to Dr Hutson for compiling records from the Division of Entomology, and also to various planters who have aided me by correspondence.

TEA FERMENTATION.—Part I.

D. I. EVANS.

INTRODUCTION.

When withered tea leaf is rolled and then spread in layers in the atmosphere it loses its green colour and assumes a coppery tinge, while the fresh smell gradually changes to the well known aroma of undried tea. The property of changing colour and developing a characteristic aroma is made use of in determining when the leaf is ready for firing, but any standard based on such observations is essentially of an arbitrary nature and will vary with different observers. At the same time certain components of the leaf are transformed in such a way that the liquors obtained on infusing the tea gain in strength and colour. The greenish tinge observed in the liquors of fresh or withered leaf seems to disappear and red coppery liquors are obtained. This change is accompanied by a loss of pungency and briskness and the appearance of the liquors and of the infused leaf, combined with the taste of the liquors, may be taken as a criterion of the extent to which these changes have taken place during the manufacture. These transformations are generally known as tea fermentation and this process of tea manufacture is carried out according to certain arbitrary standards based on visual and sensory judgments of the changes described. A qualified success has been obtained this way, but a proper control of the process cannot be hoped for until a good deal more is known about the chemical changes which take place in the leaf and the factors which control or modify these metamorphoses. The problem of the control of fermentation will not be solved either by isolated factory or laboratory investigations, but requires a combined study under factory and laboratory conditions. In spite of an ignorance of the true nature of tea fermentation, a certain amount of excellent work has been done on the question in various countries and this serves as a stepping stone for further work. Since some of this work is reported in foreign journals and therefore inaccessible to many people on account of linguistic difficulties, it is proposed to give a short account of these investigations in these articles.

OXYGEN REQUIREMENT OF FERMENTING LEAF.

The fermenting tea leaf requires oxygen if those chemical changes which produce black tea are to take place, *i.e.*, one important process in tea manufacture is the oxidation of some component of the leaf. This was demonstrated in several ways by Bamber (*Chemistry & Agriculture of Tea*, 1893, 227), who showed that freshly-rolled leaf will remain green when placed in a vacuum or under an inert gas like carbon dioxide. He found that the air in contact with the rolled leaf could be replaced by pure oxygen without

detriment to the fermentation, and naturally came to the conclusion that a supply of oxygen or air was essential. The amount of oxygen used up by the leaf during fermentation was measured by Mann (*The Fermentation of Tea.* 1907, Pt. II., 11) who found that on the average $4\frac{1}{2}$ pounds of fermenting leaf exhausted the oxygen from one cubic foot of air. Bosscha and Brzeskowsky (*Med. v. Proefstation v. Thee*, 1916, 47) found that the utilisation of oxygen by the leaf was accompanied by the production of carbon dioxide and record the following figures from one of their experiments in which they analysed the air in contact with the fermenting leaf for carbon dioxide and oxygen:—

	C.C. CO_2		C.C. CO_2
50 cc. of air at the beginning of the experiment	0·1	...	10·0
	0·15	...	9·9
50 cc. of air at the end of the experiment	8·2	...	0
	8·5	...	0

They observed that the flask in which the fermenting leaf was placed did not contain enough oxygen to complete the fermentation of 200 gms. of leaf which remained greenish until the flask was opened, when the leaf quickly attained the normal coppery colour. If rolled or crushed leaf was allowed to lie in a current of pure hydrogen, carbon dioxide or nitrogen, it remained green and did not show any sign of fermenting.

The absorption of oxygen with the production of carbon dioxide is characteristic of respiration in plants and animals, and the tea leaf is no exception to this. I have measured the respiration of the tea leaf at 18°C in a crude way and found that 40 gms. of fresh leaf produced 13.9 c.c. of carbon dioxide in one hour and absorbed 17.4 c.c. of oxygen in doing so. This gives a value of 0.8 for the ratio CO_2/O_2 for fresh leaf. The respiration decreases as the leaf loses moisture during withering, and 40 gms. of withered leaf only produced 9.8 c.c. of carbon dioxide in one hour. The volume of oxygen used up by the same leaf was 11.0 c.c. so that the ratio, $CO_2/O_2 = 0.98$, is a little higher but still of the same order. When the leaf was crushed, however, 40 gms. of leaf produced 3.4 c.c. of carbon dioxide, but at the same time absorbed 26.0 c.c. of oxygen. The oxygen uptake of crushed withered leaf is therefore considerably greater than that of uncrushed leaf, and the ratio, $CO_2/O_2 = 0.13$, is therefore of a very different order from that for fresh or withered leaf. The respiratory process is therefore upset when the withered leaf is crushed, and during fermentation the normal process of respiration is not observed. The utilisation of oxygen by crushed leaf proceeds rapidly for the first 3-4 hours and then slows down as will be seen from Fig. I. This is in keeping with observations of the rate at which fermentation proceeds in the factory

and further supports the contention that oxygen is essential for tea fermentation. The important rôle played by the oxygen of the air in tea manufacture thus makes it necessary to have a proper system of ventilation in the fermenting room so as to remove any carbon dioxide which accumulates as a result of the respiration of the leaf, and to supply plenty of oxygen for the oxidative changes.

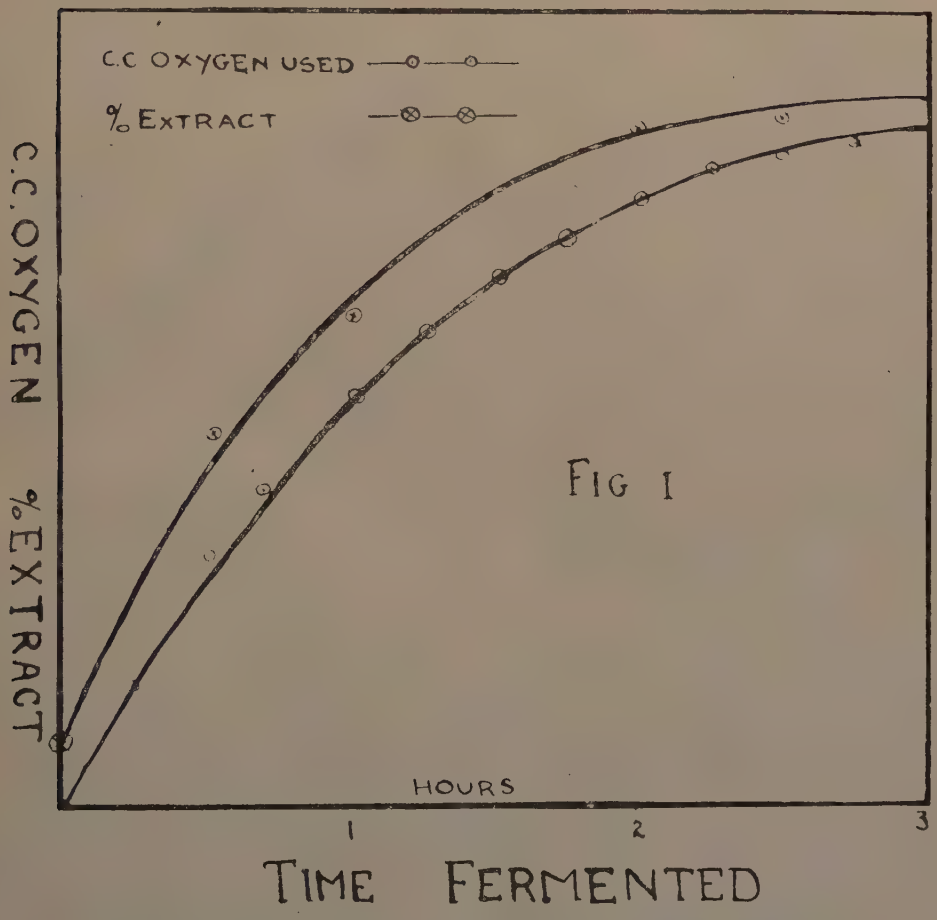

FIG 1

CHEMICAL CHANGES OBSERVED DURING FERMENTATION.

The oxidative process is accompanied by certain changes in the soluble constituents of the leaf, and these changes have been studied by several workers by comparing the chemical composition of the made tea with that of fresh leaf and green tea. Any difference in composition of the made tea from that of fresh leaf is

then attributed to fermentation. Kozai found the following differences between the green leaf and the black tea made from the same leaf:—

Elements.	Percentages. In dry leaf.	In black tea.
Crude protein ...	37·33	38·90
Fibre ...	10·44	10·27
Extracted by ether ...	6·49	5·82
Other non-nitrogenous extract ...	27·86	35·39
Ash ...	4·97	4·93
Caffeine ...	3·30	3·30
Tannin ...	12·91	4·89
Water-soluble material ...	50·97	47·23
Total nitrogen ...	5·97	6·22
Albumin ...	4·11	4·11
Starch ...	0·91	0·12

On examining the above table, it will be seen that it is the tannin which undergoes most change during manufacture, and that the other substances are not appreciably altered in amount.

Nanninga (*Korte Berichten uit S'Land Plantentuin*, 1901, 12 and *Technologie du Thé*, 1926, pp. 141-164), studied the transformations undergone by the leaf constituents by extracting the leaf with different organic solvents as well as water. The solvents used were chloroform, ether, acetic ether, alcohol and water, but although this work is of great interest, it is too academic in character to give a proper account of it in an article of this nature. Suffice it to say that Nanninga came to the following conclusions which are in agreement with those of other workers:—

(1) The same kind of changes occur during the fermentation of Java or Assam teas.

(2) The longer the fermentation the greater the decrease in free tannin.

(3) The longer the fermentation the more insoluble products are formed, and a knowledge of these changes affords a possible chemical criterion of when to stop the fermentation.

Bamber also found a decrease in the tannin content of the leaf during manufacture (*Proc. Planters' Association of Ceylon*, 1900, 94.) and states that as a result of several experiments and analyses it was found that the same changes were obtained in every case.

Mann (*The Fermentation of Tea*, 1906, Pt. I; 1907, Pt.II) studied the effect of fermentation on the water soluble material of the leaf and came to the conclusion that the soluble matter including the tannin decreases immediately fermentation sets in, and that at first the decrease is proportional to the period of fermentation.

Fermentation is thus accompanied by a loss of soluble material in the leaf, and this loss is mainly due to a loss of tannin bodies. The decrease in soluble material proceeds rapidly as soon as the leaf is crushed in the rolling, but the rate at which it goes on diminishes in time so that after 5-5½ hours there is very little change observed.

However, along with the decrease in the soluble material, fermentation also results in the production of red coloured liquors, and a probable explanation of this phenomenon has been given by Deuss (*Meded. v.h. Proefstation v. Thee*, 1913, 27) who studied the chemistry of tannin separated from the tea leaf. Nanninga (*Meded. uit S'Land Plantentuin*, 1901, 46.) had already isolated tannin from the tea leaf and described it as a crystalline powder, which is strongly hygroscopic and is rapidly changed to a brown syrupy mass on exposure to the air. Deuss used a different method for purifying the tannin but failed to obtain a crystalline product. He was able to precipitate the tannin from solution in the form of white flakes which could be dried off to a white powder for analysis and characterisation. This compound had a molecular weight of 740, and the molecule contained eight phenolic groups but no carboxyl groups. It reduced ammoniacal silver solutions and Fehling's solution, and gave a yellow precipitate with phenyl hydrazine. Deuss points out that these reactions indicate the presence of ketone groups in the molecule and that these are probably important groupings when the changes which tannin undergoes during fermentation are considered. Ordinary tannin contains only six phenolic groups, so that the tannin isolated by Deuss from tea is different from ordinary tannin. Tea tannin was found to be exceedingly unstable in the presence of impurities or small quantities of water, and it readily forms red derivatives called phlobaphenes. On account of this property Deuss classifies tea tannin with the group of oak tannin which also gives red derivatives on treatment with acid. These red products are soluble in an aqueous solution of tannin, and it is suggested that the coppery colour of made tea is due to the formation of these compounds and their subsequent solution in the tannin liquors of tea. If the oxidation is allowed to proceed too far then brown oxidation products are formed and the liquors are dull. Whether red or brown oxidation products are formed seems to depend in some way on the humidity of the air surrounding the leaf.

I have followed some of the changes which take place in the fermenting leaf, and the results obtained are in agreement with those of the other workers. It will be seen from Table I. how the constituents of the leaf vary in amount during the process of manufacture.

TABLE I.

Changes in the composition of the tea leaf during rolling and fermentation.

Leaf Material	Percentages.				
	Extract.	Total Tannin.	Acid-soluble tannin.	Non-tannin substances.	Nitrogen in extract.
Withered leaf	41·7	17·0	16·0	24·7	1·65
Leaf rolled 15 mins.	40·5	16·7	15·4	23·8	1·62
Leaf rolled 30 ,,	39·4	16·0	14·5	23·0	1·62
Dhool fermented 30 mins	38·6	15·0	12·6	23·6	1·67
,, ,, 60 ,,	38·1	14·6	12·0	23·5	1·66
,, ,, 90	37·3	14·1	11·3	23·2	1·67
,, ,, 120 ,,	37·2	13·9	11·2	23·3	1·65

The water-soluble material of the leaf as depicted by the extract decreases as soon as the leaf is rolled and the fermentation started as a result of gently crushing the leaves. The tannin content follows the extract, but the loss of tannin does not represent the total loss of soluble material since there is a slight decrease in the non-tannin fraction of the extract. More than 50 per cent. of the decrease observed in these substances appears to take place during the first roll. In spite of this the decrease in the extract may be taken as a fairly good guide of the decrease in the tannin fraction. The weight of extract rendered insoluble between each determination was 1.2, 1.1, 0.8, 0.5, 0.8, 0.1, and the loss in tannin between the same periods was 0.3, 0.7, 1.0, 0.4, 0.5, 0.2. These figures show that the process which renders the tannin insoluble slows up after a time so that the observed change is very slow after a few hours. Further, when the rate of decrease in soluble material is compared with the rate at which the fermenting leaf takes up oxygen (Fig. 1) it will be seen that the two curves follow each other very closely, and this fact supports the contention that the decrease in soluble extract observed during fermentation is connected in some way with the absorption of oxygen from the atmosphere. Since most of this loss is due to the disappearance of the tannin in the leaf, it is fair to assume that one of the processes in tea fermentation is the oxidation of tannin.

The change in the tannin from a soluble to an insoluble compound, however, is not the only transformation observed, as it is well known that the colour of the liquors becomes redder. According to Deuss this is due to the formation of tannin red which then dissolves in the tannin solution obtained when the tea is infused with water. At the same time there is formed a water-soluble substance which is precipitated on acidifying the solution. This substance is not present in the liquor obtained from fresh or withered leaf, but

when the liquors of rolled or fermented leaf are acidified it is immediately precipitated as a brownish, flocculent precipitate, leaving a perfectly clear but coloured supernatant liquor. This precipitable substance is formed in increasing quantities as the leaf is allowed to ferment, and in the experiment which gave the results shown in Table I., it increased as follows:—1.0, 1.3, 1.5, 2.4, 2.6, 2.8, 2.7. In the experiment under consideration withered leaf is shown as containing a small quantity of this material but its presence is due to the fact that it is very difficult to avoid some fermentation in withering leaf under practical conditions. When the leaf is carefully withered a precipitate is not obtained on acidifying the liquor obtained from such leaf. This product is therefore formed as a result of fermentation and a similar product can be obtained by oxidising the tea tannin in an extract of fresh leaf with iodine or permanganate and then acidfying with hydrochloric acid. In this way a flocculent precipitate is obtained as a result of the oxidation of the tannin, but it is not known as yet whether this precipitate is the same as that obtained on acidifying an extract of made tea. It is clear, however, that insoluble substances are formed when tea tannin is oxidised, and that substances of this nature are formed during the fermentation of tea, which is a further support of the contention that one process taking place during tea manufacture is that of the oxidation of the tannin complex.

Although we can follow some of the changes which the tannin complex undergoes during tea fermentation, there are other subtle transformations which are not always easy to assess. A tea extract contains a good deal of colloidal material which is liable to undergo change in its physical nature as a result of temperature and moisture conditions, and, although the chemical change involved may be very small, the effect on the physical properties of the solution is considerable. Some at least of the tannin complex of tea exists in this form and its state of aggregation appears to be changed during the process of tea manufacture, but nothing appears to be known concerning the colloidal properties of a tea extract although this promises to be a fertile field for investigation.

Finally, it will be observed that the nitrogen extracted by hot water remains very constant in all the extracts and it is thus concluded that the nitrogenous compounds do not play a very important part in tea fermentation.

(*To be continued*)

THE HEATING OF FERMENTING CHAMBERS.

(REVIEW.)

Some of the estates situated at a high elevation in Java (5,500 ft.) at times find the morning temperatures so low that a good fermentation is not possible unless the fermenting rooms are warmed. The Tea Experiment Station at Buitenzorg recommends a temperature of 22°C. (71.6°F.) for a proper fermentation, and a system of heating is being successfully applied on various estates in order to attain a condition of high humidity coupled with a temperature of 22°C. in the fermenting room.

A simple stove has been used on some estates with satisfactory results, and at Sinambra the fermenting room is warmed by means of a hot water pipe which passes through the dryer stove into the fermenting room. The use of steam seems to be well suited for heating a room and maintaining the humidity, but it is not satisfactory unless the air supply is controlled and the chamber well insulated against heat losses. F. Harman and G. A. Golliez (*Archief v.d. Thee Cultuur*, Nos. 1 and 2 June, 1929.) describe a heating and humidifying installation by means of which the temperature, humidity and air supply can be controlled.

The fermenting chamber is built of stone and brick, fitted with two glass windows for lighting purposes, iron roofs with a double ceiling of some insulating material, and the doors leading into the rolling room fit well so as to prevent draughts and currents of air. The arrangement comprises a heating installation consisting of a Sultzer steam generator, placed outside but connected by means of a pipe to the ventilator which is fitted with a steam hose inside the fermenting chamber, and a system of humidifiers.

The ventilator may be used to suck the air of the fermenting chamber, the outside air or a mixture of the two as desired, and it drives the air sucked in over the steam hose from the generator. The air is thus warmed and driven in every direction into the fermenting chamber, and by a proper adjustment of the mixture of air taken in from the fermenting room and outside any desired temperature can be obtained. When the fermentation is over the ventilator connection to the fermenting chamber is closed, but the opening to the outside air is opened fully so as to draw outside air into the room to cool, freshen and dry it.

The heating installation is worked in conjunction with a battery of Sultzer sprays which are placed at such a height in the fermenting room that the air blown in every direction from the heating apparatus comes above the sprayers, and is forced to travel through a zone saturated with water. In this way the fermenting chamber is warmed by mixing the atmosphere of the room with outside air, forcing

this air through steam so as to raise its temperature, and then humidifying the warmed air by forcing it through a spray of water. It is claimed that the air temperature can be maintained at 22°C. and 95 per cent. relative humidity, while the tea made is even, highly coloured, of good strength and flavour, and the aroma is much better than when the fermentation was carried out at a low temperature.

The installation is worked as follows: when the proper steam pressure has been generated the ventilator is started and hot air is blown into the chamber for an hour, so that the temperature rises to 25°C. The humidifier is then set going and the temperature drops to 22°C., after which the temperature remains nearly constant at a relative humidity of 95 per cent.

The temperatures of the fermenting rooms up-country in Ceylon are considerably below 70°F. at certain periods of the year. During the dry months of January and February the temperature may be well under 60°F., but whether this is desirable or not is not quite certain. It is agreed that the best tea is made when low temperatures are possible for fermentation, although it is evident that fermentation is very slow and uneven. This trouble is combated by spreading thicker so as to retain the heat developed in the leaf and thus hasten the fermentation, and yet cool temperatures are said to be desirable in spite of the fact that everything is done to counteract them during actual fermentation. There are many other factors which make for fine quality during the cold, dry weather, such as slow growth, smaller crop allowing careful transport and manufacture, ideal withering conditions, and, what I think is very important, cool conditions for *rolling* not for fermentation. When the leaf is rolled heat is developed and the temperature of the leaf may become so high inside the roller as to affect the quality. Cold temperatures during the rolling period help to dissipate such heat, keep the leaf cool, and afford a satisfactory cooling of the leaf during roll breaking. Even then it will be found that the temperature of the leaf will be over 70°F., so that one part of the leaf is fermenting in the roller at 70°F. or more, and the dhools are expected to do this at about 55°F. When the rolling room is hot then the heat developed in the rollers cannot escape, the temperature of the leaf is too high, and it is quite possible that the room temperature may then be too high even for the fermenting dhools. Cold temperatures are therefore ideal for rolling in that the leaf is prevented from overheating, but the temperature can be, and often is, too low for a satisfactory fermentation of the dhools, and it is possible that a closer attention to the temperature of the fermenting rooms up-country would cause an improvement in the fermentation.

D. I. EVANS.

CASSIA MULTIJUGA.

(REVIEW.)

In view of the difference of opinion regarding the utility of *Cassia multijuga* as a shade tree for tea (cf. *Tea Quarterly*, **1929**, 2, 25), it is of interest to note the views of another observer from Java, Herr P. M. Prillwitz, published in *De Bergcultures*, **1929**, **63**, 1606. The tree which was introduced to the Dutch East Indies from tropical America has been used chiefly for purposes of ornament, but was eventually planted in the experimental plots of the Tea Experiment Station from which stumps were sent out to various estates. The tree is considered a rapid grower, exhibiting at an early age a tendency to branch and spread out. Its habit of profuse flowering is a less favourable consideration, while without special pruning there is a considerable dying back of the branches. The tree appears to be susceptible to the attack of a red root fungus (*Ganoderma pseudoferreum*), but other important diseases and pests have not yet been described. The wood is of better quality than *Albizzia falcata*, but the amount of wood formed is, however, considerably less at equal ages. Breaking of the branches by wind was occasionally observed.

The experiments of Herr Keuchenius indicate that root nodules are seldom or never found on *C. multijuga*, and it is considered possible that nitrogen fixation takes place through other agencies, *i.e.*, by *mycorrhiza*. Symbiosis between fungi and higher plants is of course known but is rare in the case of leguminous species in which *B. radicicola* is the usual nitrogen fixing organism. This question is receiving further examination.

The author comes, however, to the conclusion that *C. multijuga* cannot be considered a better shade tree than *A. falcata* or dadap as originally suggested by Herr Koch but considers that further experiments are desirable.

ROLAND V. NORRIS.

NOTICES.

Entomologist.—Mr. C. B. Redman King, M.A., reported his arrival in Ceylon on the 9th December.

Advisory Work.—Dr. C. H. Gadd having returned from leave, mycological specimens and enquiries should, in future, be directed to Nuwara Eliya and not to Peradeniya.

Entomological enquiries should be addressed to Mr. King at Mahagalla Bungalow, Norwood. Specimens despatched by train should be sent to Hatton Station, c/o Mr. H. E. Fernando, Forwarding Agent.

Visitors' Day.—Tht first Wednesday in each month has been set aside as visitors' day at St. Coombs Estate, when it is hoped any one interested will visit the Station. Visitors at other times will also be welcome, but the Superintendent may not be free to show them round. Visitors on arrival at the Factory are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the Mattakelle turn-off, opposite milestone 28/10 on the Nanu Oya-Talawakelle main road. A sign-post has been erected at the turn-off.

ROLAND V. NORRIS.
Director.

EDITORIAL.

In the present issue will be found an outline of some of the field experiments to be laid down at St. Coombs in the present year. The attention of readers is drawn to the section on cover crops and to the request there made for any information which planters may be able to give to the Institute in regard to trials they may have carried out with different species. The number of such crops that have been tried on various estates must now be considerable, and we believe it would be of distinct benefit if the information and experience thus obtained could be collected and made more generally available. In this way it should be possible to arrange for more extended trials of crops which have been found suitable to particular areas while, at the same time, other species, which have definitely been found unsuitable, could be eliminated from further consideration.

It is asked, therefore, that planters who are willing to assist the Institute in this direction will kindly furnish us with details regarding different species of cover crops tried by them. In particular, information will be welcomed on such points as (I) Rapidity of growth or difficulties found in establishing the crop, (II) Quality of cover formed, (III) Nature of growth, *i.e.*, woody or leafy, spreading or climbing, etc., (IV) Response to cutting and amount of green manure obtained, (V) Treatment given to the crop, *i.e.*, planting, cultivation, frequency with which cut back, etc., (VI) Ill-effects, if any, observed on the tea, etc., etc. Details as to rainfall and elevation of the estate should also be added.

The above appeal for information on the subject of cover crop may, however, be enlarged into a more general request for information regarding experiments carried out by planters either in regard to cultivation, treatment of diseases and pests, factory practice or any other aspects of their work. The amount of valuable work carried out in this way must be considerable but the results are not generally available and in many cases are eventually lost sight of.

Information is constantly sought on such points as different methods of pruning, the most suitable time for applying manures, particularly pruning mixtures, the incidence and spread of insect and fungus diseases, and the response of such diseases to different treatments, the control of factory processes, etc., etc. It is felt that the Institute should be in a position to act as a clearing house for the broadcasting of all available information on such points, but this can only be possible if planters will co-operate to the fullest possible extent by keeping in touch with the Institute and placing the staff in possession of results which they may consider to be of any general interest. The Institute will always be glad to publish in the *Tea Quarterly* any contributions of general interest which planters may care to make on matters of estate practice and cordially invites such articles.

ROLAND V. NORRIS,
Director.

THE FIELD EXPERIMENTAL PROGRAMME FOR 1930-31.

The removal of the Institute to St. Coombs in the latter part of the year will make possible a considerable expansion in the field work contemplated by the staff. Although the appeal for information concerning field problems made by the writer at the Institute's conference in March, 1929 produced negligible results, plans for the experimental programme have been a matter of constant discussion and the definite proposals made by the staff were agreed upon by the Field Experimental Sub-Committee at a meeting on February 25th, 1930. The personnel of this Committee is made up of the Chairman of the Board, the Director and Agricultural Chemist on the staff side, the Visiting Agent and Superintendent on the estate side, and two planting members.

PRELIMINARY DATA.

The experiments will begin as soon as personal supervision on the spot can be provided for, but in the meanwhile a good deal of preliminary work is being put in hand. As far as tea is concerned, work will commence with the pruning due in October. Suitable areas on the mature tea have already been reserved and will shortly be sub-divided into the necessary plots. Even such rudimentary work as plot division involves considerations of much importance from the point of view of the usefulness and accuracy of subsequent experiments, and the experience gained during the last two years on the Scrubs Uniformity Trial will be utilised to the full. The results of this trial, which has involved the collection of just over six-thousand yield records, have given indications of the best size and arrangement of plots to employ, that is to say, the formation which gives the smallest possibility of error with the most economical utilisation of land. It is now possible to say at what plot size diminution of error virtually ceases. Consequently, no useful purpose would be served by using plots of a larger and therefore more unmanageable size. Prior to the commencement of the experiment proper, this preliminary work will be pushed a stage further. The Scrubs results are of general application in so far as they show the trend of error with increasing enlargement of the plot. It does not necessarily follow that the actual size of the errors encountered on St. Coombs tea will be exactly of the same dimensions. Consequently, in addition to establishing plots which give the lowest error, it will be advisable to assess the magnitude of that error beforehand. This will be done by cropping the untreated plots for a period of at least three months before pruning and thus obtaining the actual errors associated with

the particular area of land. In the light of this more precise knowledge, a multiple of replications can be decided on which will give a final error value to the proposed experiment low enough to distinguish with certainty the validity of any response which subsequent treatments may produce. Work of this kind is as important in starting field experiments as the calculation of stresses and strains is for the engineer building a bridge, for without such investigation there is grave risk of both endeavours breaking down.

MANURIAL EXPERIMENTS.

The experiment which is assigned to this prepared site is manurial, and will involve two main questions:—

(1) What are the relative availabilities of inorganic and organic artificial nitrogenous manures and their responses ?

(2) What is the response of tea to potash ?

Since it is probable that as in other crops the response to nitrogen is conditioned by supplies of potash and *vice versa*, the experiment will provide for plots at varying levels of nitrogen and potash supply. The general scheme, as it affects nitrogen and potash in their quantitative aspects, may be summarised in the following diagram of the nine treatments proposed:—

		0	1	2	Units of potash
	0	**00**	**01**	**02**	
Units of	**1**	**10**	**11**	**12**	
Nitrogen	**2**	**20**	**21**	**22**	

Within the limits of the experiment, every possible combination of potash and nitrogen finds a place. The question of *kind* of nitrogen will be superimposed on this design. There are six plots receiving nitrogen. These will be divided between the three qualitative sources—sulphate of ammonia, cyanamide, and bloodmeal. These are all manures in common use and they involve respectively an increasing number of stages in decomposition before they are available to the plant as nitrate. In the division provision will be made so that over the whole experiment each kind of nitrogen will be associated with exactly the same range of potash and nitrogen quantities.

We may consider now the advantages that this somewhat complicated arrangement of treatments involves. We shall aim tentatively at a replication of sixfold. There will accordingly be 54 plots in all. Taking the question of the effect of increase in the amount of nitrogen as a first illustration, it will be seen that in each replication there are three plots receiving no nitrogen, three with one unit, and a like number with two units. These are associated with different amounts of potash, but each nitrogen treatment is associated with

similar potash groupings, and so for the purpose of nitrogen comparison they can be lumped together, *i.e.*, the first horizontal row of the chart summed up can be compared with the second horizontal row, and so on. Taking replication into account, there are thus $6 \times 3 = 18$ plots from which to argue about each level of nitrogen nutrition.

Similarly, with the other questions, as set out in the following table:—

	No. of comparable plots.
Nitrogen comparisons (quantities)	18
Potash comparisons (quantities)	18
Nitrogen comparisons (qualitative)	12

By thus making every plot dovetail into every question postulated, we have increased the effective replication in two cases threefold and in one twofold. This means a corresponding (though not proportional) reduction in error and a great gain in accuracy.

The results of this experiment will help in building up a scheme for a further manurial experiment which is of particular interest at present. A question that is being continually asked of the Institute is whether manure mixtures can be made less costly by substituting inorganic nitrogen fertilisers for the organic nitrogen which is largely used at present. In addition to the information culled from the previously described trial, it is important to know whether any differences in efficiency between inorganics like sulphate of ammonia and organics like whale guano and bloodmeal are levelled out in the presence of adequate supplies of organic matter. In order to put this to the test an experiment has been projected in which inorganic nitrogen is pitted against organic nitrogen on two areas similar in all respects, except that one is to be kept at a low humus content whilst the other will be artificially raised in humus content.

The tea upon which this experiment will be placed is not yet in bearing, and this gives a margin of time for preparing the high humus area. The type of green stuff employed is not vital, so in order to obtain quickly large quantities, nurseries of sunflower have been laid out which will be cut, weighed and carted on to the adjoining site. A study of the differential effects of the nitrogen manures on these two areas should give information of considerable practical interest.

COVER CROPS.

In the evidence given by the Institute to the Soil Erosion Committee an undertaking was given to further preventative schemes by arranging for experiments. This promise is to be implemented this coming season in two directions, whilst further plans are in mind for later work.

In stressing the possibilities of using cover crops as preventatives of erosion, the Institute is conscious that the choice of suitable species is a difficult one, and that the proper management of cover crops in tea under Ceylon conditions still requires a great deal of attention.

A site has been reserved for trying out a range of cover crops and for establishing plots upon which the growth, yield, response to cutting and cultivation, and general suitability can be tested, and on which the complementary soil amelioration can be followed stage by stage. It is realised that many planters have accumulated on their own estates valuable information regarding individual species. In the nature of things, however, the comparison of species and methods on different estates is hampered by variety of procedure. At St. Coombs, procedure can be standardised with benefit to the number of comparisons available. It will be of great service to the Institute if planters will place their knowledge at our disposal by writing to us, giving the names of species which have prospered on their estates. Details of methods of treatment, altitude and rainfall, and an intimation as to whether they could supply small quantities of seed will also be valued.

By such co-operation the time taken in finding and testing the most promising material will be considerably shortened.

DRAINAGE.

The second aspect of soil erosion prevention upon which experiments have been prepared is that of drainage. Until some detailed knowledge about the water absorption of tea soils and rates of percolation has been collected, it is very difficult to determine the relative efficacy of the various systems of drains now advocated. With a view to obtaining such data, an area of $1\frac{1}{4}$ acres on a slope of 1 in 4 has been bunded into 10 ft. locks by means of concrete blocks. On the area concerned there are 80 such locks. The lock bottom is levelled in each case to increase capacity, and by the daily measurement of rainfall, run-off and percolation, the distribution of the precipitation will be followed from season to season. Since such systems appear not only to arrest soil but to affect the soil moisture balance, the actual soil moisture content and soil temperature will also be periodically examined.

This completes the immediate programme, preparatory work for which has already been set in hand. Details of progress will be reported in this journal from time to time.

T. EDEN,

Secretary, Field Experimental Sub-Committee.

WHAT IS THE DIPLODIA ROOT DISEASE OF TEA ?

C. H. GADD, D.Sc.

Diplodia root diseases of tea have been recorded from India, Ceylon, Java and Nyasaland. The symptoms, however, do not appear to be alike in all countries; the only character common to them all is the presence of a particular fungus, *Botryodiplodia theobromae*, on the roots of affected plants, usually, after death.

Botryodiplodia theobromae is a common fungus throughout the tropics, where it is found in forest and grassland as well as in arable land. In general, it is saprophytic, *i.e.*, it feeds on dead tissues, though there is some evidence of its parasitism on certain plants such as cacao, sugarcane and Hevea rubber. On tea also there is some evidence of its parasitism, but the fungus is so very prevalent that were it able to attack healthy tea bushes indiscriminately, few would survive.

When such a common fungus is constantly associated with diseased bushes, there must always be some doubt that it is the cause of the disease until definite experimental proof is produced.

It will be admitted that if water is withheld from the roots of a tea bush, that bush will ultimately die just as a neglected pot plant will die for lack of water. Tea bushes which have died in Ceylon under conditions such as would warrant a conclusion that they had died of drought, invariably, in the writer's experience, bear the fungus *Botryodiplodia theobromae* abundantly on the dead roots. The fungus is probably there by accident owing to its ubiquity, and its presence cannot be regarded as evidence that the fungus played any part in causing the death of the bush. The fungus may possibly have hastened the death of the roots, but, even in that case, it can be regarded as of little economic importance. Such deaths are best attributed directly to drought.

When bushes die from an unknown cause and the roots are found to be constantly infected by the same fungus, *Botryodiplodia theobromae*, there is no more justification, from that fact alone, for the conclusion that the fungus caused their deaths, than there is for drawing a similar conclusion in the above-mentioned cases of drought. At the same time it would be unwise to conclude that because a fungus is a very common saprophyte it, therefore, cannot be parasitic under any conditions. As already stated, there is some evidence that *Botryodiplodia theobromae* becomes parasitic on certain host plants, but where it is known to cause damage it is either a wound parasite or a follower of some other disease.

Bearing these points in mind, it is not very surprising that diseases of the tea bush, the causes of which are obscure and which exhibit very different external symptoms, have been ascribed to Diplodia owing to the constant presence of that particular fungus on the roots. Thus, there is not one Diplodia root disease of tea but many. To call them all by one name, whether that name be Diplodia or internal root disease, is not helpful to the practical planter whatever it may be to the mycologist. So long as the name Diplodia disease of tea is retained, it should be regarded as a group of obscure diseases. As each disease is investigated and its true cause ascertained, it will be necessary to give distinctive names to the individual diseases.

The writer (1 and 2) after investigating the common Diplodia tea root disease in Ceylon, viz., that in which apparently healthy, mature tea bushes die after pruning, arrived at the conclusion that the deaths were a direct result of a deficiency of internal food reserves at the time of pruning. In every case examined, the roots were destitute of starch. Tunstall (7) does not find the same absence of starch in Diplodia diseased tea bushes in North-East India. He states "Bushes have been frequently observed with roots and trunk so badly attacked by the Diplodia fungus that the wood was darkened throughout yet containing abundant starch. Such bushes produce new shoots after pruning but after the latter had attained some length they died back." The writer has also seen Diplodia infected roots which contained abundant starch, but these were obtained from a bush in full leaf which had died of drought, not from a bush affected by the common Ceylon Diplodia disease.

No claim has been made that deaths from all so-called Diplodia root diseases are the result of deficiencies of internal reserves. That conclusion applies to one of the Diplodia diseases only, namely the common Ceylon form which is always associated with pruning. This form of Diplodia disease now requires a distinctive name to distinguish it from the other Diplodia root diseases of tea.

It is not surprising that Tunstall should obtain different results if his investigations were carried out on a different form of Diplodia root disease of tea. That such is possibly the case is evident from the published descriptions of the disease as it occurs in North-East India.

The first record of a Diplodia root disease of tea was made by Watt and Mann (8) from the Bishnath district of Assam. The disease occurred on young plants three or four years old, growing on grassland. "There is little to show on the surface of the root as to what is the cause of the death of the plants. The leaves of the plant take on a yellow appearance, in which the network of the veins is very

prominently seen (an appearance easily recognised after a little practice), and then they begin gradually to fall off and, branch by branch, the bush dies."

The disease here described has definite symptoms; it is a disease of young plants which have never been plucked and which exhibit peculiar leaf characters.

A more recent acccount of the Diplodia disease in North-East India is given by Tunstall (7):—

"The symptoms of the disease are not the same in all cases. A plant may be affected for many months and yet continue to look healthy. Suddenly, without any warning, the bush dies with all its leaves attached as though it had been struck by lightning. In other cases, the leaves may take on a yellow appearance and the veins darken a little in colour, defoliation then occurs gradually and the bush dies branch by branch."

"The most serious losses, caused by the fungus, are on young tea, *i.e.*, plants up to three years of age. It frequently happens that at the beginning of the season when the early rains have fallen, here and there in a new clearance an apparently healthy plant dies suddenly without any apparent reason. Others, at the same time, begin to look sickly . . . . . The same sort of thing happens on all classes of soil, but is most frequent on coarse, sandy soils subject to drought. Mature and old tea plants on such soils also die in a similar manner in the rainy season succeeding a long period of dry weather."

This description includes that given by Watt and Mann, but has been extended to include another Diplodia disease of tea or an extension of the same disease to old tea. It would appear that the disease in North-East India occurs principally on young tea and is more intimately associated with drought conditions than with pruning, though "for some reason or other pruning accelerates the last stage (of the disease) and the plants die about six weeks after pruning."

The first account of a Diplodia disease of tea bushes in Ceylon was given by Petch (4) in October 1910. A fuller description (5) was published in 1923 from which the following extracts are taken:—

"In its most common form, this root disease only comes into prominence after pruning. Sometimes the pruned bushes, which may have appeared perfectly healthy before pruning, fail to produce any new shoots and die off completely. In other cases, the green shoots grow to a length of about six or eight inches and then begin to die. Their leaves become mottled with yellow, and then turn black, the latter change occurring first at the tip, or along the edges and ultimately extending over the whole leaf . . . . Finally, the leaves fall and the whole shoot becomes dead and black down to its base. This condition may begin on one or more of the main

branches, and gradually extend over the whole bush, or it may remain confined to one branch. In the former case the whole bush dies, in the latter only the branch affected; and all intermediate stages may be found. The disease usually appears from six weeks to three months after pruning."

"In Ceylon, this disease is commonest on old tea, but is by no means confined to that. Several cases have occurred on tea after the first pruning, and on badly affected estates it has killed out nursery plants."

From the first sentence of the foregoing quotations it would appear that there is a less common form of this disease in Ceylon which is not associated with pruning, *i.e.*, in which the fungus attacks the bush while in full leaf. If so, it is possibly referred to by Petch in the following sentences: "When Albizzias (*Albizzia moluccana*), planted through tea, are allowed to grow to a large size and are then ringed or cut down, and the stumps left to decay *in situ*, root disease frequently attacks the surrounding tea bushes. In some instances, this is due to *Ustulina zonata*, but when a large number of bushes die, twenty or more, round an *Albizzia* stump, the cause is usually *Botryodiplodia*. The fungus develops on the dying Albizzia stump, and its spores subsequently infect the neighbouring tea." This form of the Diplodia disease has been very rare in Ceylon in recent years, and has not come within the writer's experience.

In *old* tea, after pruning, the disease occurs mainly at elevations below 2000 feet on all types of soils. Bushes which are partially affected, *i.e.*, those which successfully produce new shoots on one or more of the main branches, develop no further symptoms and exhibit normal growth till they are next pruned. In other words, the disease is only evident immediately after pruning. In *young* tea which has never been plucked, the disease is not confined to low elevations; in fact, it is best known to the writer at higher elevations, and the cases he has had under observation do not develop normally when they survive their first pruning. The bushes have a general sickly appearance though the symptoms are not, in all cases, identical.

It is possible therefore to divide the Diplodia disease, as it is described by Petch from Ceylon, into three forms based on their general symptoms:—

1. In old tea after pruning—the commonest form.
2. In young tea after its first pruning and in nursery plants.
3. In tea in full leaf—rare.

It may be possible later to distinguish the disease as it occurs in nursery plants from that which develops after young tea is first pruned in the field, but for the purpose of this article the division of form 2 is unnecessary.

The symptoms of the common form of Diplodia root disease in Ceylon differ markedly from those exhibited by the disease in North-East India. The North-East India disease approximates to that known on young tea in Ceylon, but there is some doubt that the two are identical. Leaf symptoms characteristic of the Indian disease have not been recorded on young tea in Ceylon, though they have been observed on bushes affected by the disease or group of diseases known as Witches' Broom.

Diplodia root diseases of tea are also known in the Dutch East Indies and in Nyasaland. Steinmann (6) reports that this root disease was first noticed in Java in November, 1926, after a very severe drought, when it caused very severe losses in nursery plants and young and old tea.

Of the disease in Nyasaland, Dr. Butler (3) writes "Cases of the root disease caused by this fungus (*Botryodiplodia theobromae*) were not common in Nyasaland, except in young tea, during the period of my visit. Mature dead bushes were never found to have more than an occasional root infected . . . The only instances in which bushes appeared to have been killed by *Botryodiplodia theobromae* were in the first and second year after planting out and such attacks were always sporadic."

This brief review suggests the possibility that the Diplodia or internal root disease of tea is not a simple specific disease, and that diseases with probably different causes have been classified as Diplodia diseases, mainly because of the constant presence of the fungus *Botryodiplodia theobromae* on their roots. That fungus may be there as a causative factor or merely accidentally as a common saprophyte. The exact meaning of its presence has to be determined for each individual disease before its true importance can be ascertained.

This view is also suggested by Butler, who in a report on an obscure tea disease in Nyasaland (3)—a disease which he regards as "unquestionably one of the most serious diseases to which the tea bush is liable"—points out that the above ground symptoms are somewhat similar to those of the Diplodia disease seen by him in Assam in 1902, and described by Watt and Mann. He also suggests the possibility that the disease occurs in the East but has been confused with the effects of Diplodia.

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TEA FERMENTATION.—Part II.

D. I. EVANS.

THE DEVELOPMENT OF AROMA DURING FERMENTATION.

The aroma and flavour of tea has been ascribed to the presence of volatile constituents, and several attempts have been made to isolate the essential oil of tea by distilling large quantities of fermenting leaf with steam, but the amount of oil separated has been too small for its proper study. Van Romburgh and Lohmann (*Meded. v.h. Proefstation v. Thee*, 1912, 19.) are reported to have obtained 1 c.c. of oil from 15 kilos (30 lb.) of freshly fermented leaf. The oil obtained was a yellow liquid, with a smell resembling that of tea but so strong as to be disagreeable and even objectionable. Romburgh and Lohmann, contrary to Crole who also investigated the essential oil, asserted that the oil did not resinify readily but remained liquid when kept in a stoppered bottle exposed to diffused light. The reactions of the oil marked it as alcoholic in nature, and on fractionation they obtained methyl alcohol, acetone, and methyl salicylate which is an ester found in many essential oils, especially oil of wintergreen. They also isolated salicylic acid from the residue left after distillation by neutralising with dilute alkali, evaporating it down, acidifying and then extracting this with ether. They found no difference between the essential oils of Java and Assam tea, and noticed that fermentation altered the amount of essential oil which is rapidly produced during this process.

Deuss (*Meded. v.h. Proefstation v. Thee*, 1915, 42.) describes his method of separating an oil from tea leaves and gives a short account of the product obtained. He distilled large quantites of fermenting old tea leaves with water in an improvised apparatus made of drums and kerosene tins. The large volume of distillate obtained was re-distilled from the cleaned still until a quarter of the original distillate passed over. This process was repeated four times, when small drops of oil separated out on the surface of the distillate. It was necessary to repeat the distillations because the first distillates were only turbid and did not show any separation of oil. It was also essential to carry out the distillations very slowly and with efficient cooling to avoid loss of oil. The oily drops on the surface of the distillate were removed with ether or acetic ether and the resulting solution dried over calcium chloride. On evaporating off the solvent a yellow oil with a disagreeable tea smell was obtained which gave a colourless liquid when distilled under reduced pressure. The oil remained colourless for some time if kept in the dark, but after a while it became yellow again. Deuss found that the oil did not solidify for years if it was pure, and that it could be separated into

two fractions on distillation. The main fraction boiled over at 156°C, and appeared to consist of an alcohol with six carbon atoms. The higher boiling fraction passed over at 220°C, and was composed of methyl salicylate.

Finally, Gildemeister and Hoffmann are reported by Neuville (*Technol. du The*, 1926.) as claiming to have isolated an alcohol of the formula $C_6 H_{12} O$ from the main factor.

The essential oil is found exclusively in the leaves, but it only exists in very small amount, if at all, in fresh leaves. Green tea, accordingly, does not contain any essential oil, its aroma being due to the presence of other substances. This view, however, is not universally accepted as Mulder (Neuville, *Technol. du The*) states that the green tea Hyson contains more essential oil than the black tea Congou. He found 0·79 per cent. essential oil in Hyson from China, and 0·98 per cent. in Hyson from Java, but only 0·6 per cent. in Congou from China, and 0·65 per cent. in Congou from Java.

Whether it is present in green tea or not, it is rapidly produced during fermentation, and Deuss suggests that it is formed by the decomposition of a glucoside tannin which breaks up into tannin and sugar. The sugar then decomposes to form an alcohol and essential oil.

As stated before, the amount of essential oil obtained from tea is very small, and if only small samples of tea are used the distillate itself does not exhibit any separation of oily drops, but is slightly turbid. When this is shaken with ether the oil is removed, but the quantity obtained is too small to be weighed and estimated. Mann (*The Fermentation of Tea*, 1907, No. 1) tried to overcome this difficulty by determining the amount of oxygen necessary to oxidise the distillate obtained. The method, which consisted in oxidising the volatile substances with permanganate, is described in his paper and it is claimed that, although it gives no measure of the absolute amount of essential oil, it gave comparative results which were trustworthy. He found that Darjeeling teas required more oxygen for the oxidation of the material distilled from 10 gms. of tea than Assam teas. It was found possible to pick out a flavoury tea from one which had no marked flavour in accordance with a tea broker's opinion of flavour, but the method could not be applied to fresh or withered leaf because the distillates obtained with these were acid. The figures obtained for fresh leaf on the other hand were so different from those obtained with fermented leaf that it was considered possible to draw certain conclusions from them. According to Mann, very little flavour is produced during a normal wither, but a rapid development of essential oil takes place as soon as the leaf is rolled. This development continues during fermentation, but the rate slows up in time,

so that the maximum flavour is developed at an early stage of the fermentation. The usual period necessary to attain maximum development of essential oil under the conditions of his experiment was three hours. After that there was, generally, a decline in amount. This was not always true, but at times the decline was very rapid. It was suggested that this loss in flavour observed in practice was due to micro-organisms, since such a decline was not observed in experiments carried out in the presence of chloroform so as to exclude micro-organisms. The temperature at which fermentation was carried out did not seem to affect the yield of essential oil, provided it was below 86°F., but any stewing of the leaf during the firing operation caused a rapid reduction in the amount of essential oil. A tray temperature of 212°F. and over, or prolonged drying at temperatures well below the boiling point of water, also resulted in loss of flavour.

Mann sums up the result of his experiments as follows:—

(1) The whole of the flavour is very rapidly developed after the cells of the leaf are broken.

(2) The quantity of oil does not materially increase after three hours' fermentation.

(3) There is generally a decline in flavour after three hours' fermentation though occasionally the amount remains constant.

(4) This decline may, it is possible, be connected with the action of microbes in the fermenting leaf.

(5) The temperature, at any rate up to 86°F. has little influence on the formation of flavour during fermentation.

(6) Firing above 212°F. means loss of flavour, and long continued firing even below that temperature, and even with almost dry tea, also means loss of flavour.

According to Mann the time required to produce maximum flavour does not coincide with the time necessary to produce the maximum thickness of liquor. If flavour is the primary consideration, then the fermentation should be as short as possible, but if liquor is more important, a longer fermentation should be allowed. If absolute cleanliness is maintained then it is possible to prolong the fermentation in order to improve liquors without serious detriment to the flavour produced, and in this way turn out flavoury and good liquoring teas.

The methods of investigating the production of essential oil in the above work seem to have been eminently successful. It is, however, difficult to decide how many of the results obtained could be reproduced, and there are many objections to the analytical

methods used. Although the results agree well with experience gained in practice, no further estimations carried out in this way have been reported from India, and Deuss (*ibid*) makes the disconcerting statement that he was never able to get duplicate results to agree by the permanganate method in spite of all precautions taken. This detracts somewhat from the merit of Mann's work, and makes it difficult to decide what is the true value of it, so that the problem of the development of essential oil is still far from being solved.

THE TEMPERATURE RELATIONS DURING FERMENTATION.

(a) *Heat production by the fermenting leaf.*—Another characteristic of fermenting leaf is that of the production of heat. When the leaf is crushed, the oxidative change is accompanied by the evolution of heat energy. The leaf mass when emptied from the rollers is at a much higher temperature than the surrounding atmosphere, and although some of the heat is undoubtedly the result of friction, the greatest proportion of it is due to the chemical change which takes place when the leaf is crushed. In an actual test, carried out on leaf emptied from the rollers after the first light roll, the temperature of the leaf was 84°F. while the air temperature was 73°F., and after the fourth roll when fairly heavy pressure was applied the temperature of the leaf had risen to 88°F. By the time the leaf had passed over the roll-breaker and sifter the temperature had dropped to 79°F., and the fine leaf spread out for fermenting had a temperature of 73°F. The process of roll-breaking has thus materially cooled the leaf before it goes back to the roller, so that the more efficient is the roll-breaking, and the cooler the room is maintained by means of proper humidification, the greater is the cooling effect on the leaf before it goes back to the rollers. Roll-breaking thus serves the double purpose of removing the fine leaf from the coarse, and of cooling the leaf quickly at the same time, and is a process which needs careful supervision lest it be scamped. According to Deuss (*Meded. v.h. Proefstation v. Thee*, 1917, 42.) the temperature rise is greater during the first roll than during the second roll, so that the heat is developed with almost explosive force when the cell walls are crushed and the mixed juices come in contact with the oxygen of the air. This increase in temperature is also considerable in open top rollers in which the only pressure effect is that of the weight of the leaf itself.

Further, when the leaf is spread for fermentation heat is still evolved, and sometimes a rise in temperature can be observed in the fermenting leaf. The observed rise in temperature, however, depends on the thickness of spread and the rate at which this heat can be dissipated into the surroundings. When the fermenting leaf is insulated in a receptacle in the way described by Boscha and

Brzesowsky (*Meded. v.h. Proefstation v. Thee*, 1916, 47.) the production of heat is clearly demonstrated by the rise in temperature observed, as will be seen from the following data calculated from the curves given in their paper.

Table II

Temperature of tea leaf during fermentation

Period of fermentation in hours.		Temperature of the leaf in °F.
0·0	...	71·6
0·5	...	77·0
1·0	...	78·8
1·5	...	79·7
2·0	...	80·2
3·0	...	80·6
4·0	...	81·0
5·0	...	80·6
6·0	...	80·2
8·0	...	78·8

According to Carpenter and Harrison (*The Manufacture of Tea in North-East India*, 1927.) the temperature of fermenting leaf rises during the first $2\frac{1}{2}$-3 hours, and then remains steady for $2\frac{1}{2}$ hours before showing a decline. An aroma which they term "the first nose" develops just before the maximum under normal plains' conditions in India, and if the tea is fired at this point a brisk and pungent tea results. A "second nose" appears if the tea is allowed to ferment for another hour, but the temperature change has been slight during this period. This tea is stronger but less brisk than the former, and if allowed to ferment for another $1\frac{1}{2}$ hours a "third nose" is observed. The temperature may show a decline at the end of this period, but the strong coloury tea obtained is flat and lacks pungency and briskness.

Deuss (*Meded. v.h. Proefstation v. Thee*, 1917, 42.) determined the temperature of the fermenting leaf on various estates at different elevations ranging from 600-4,900 ft. above sea level. The temperatures recorded were plotted against time so that a series of curves were obtained for various elevations. The curves were very irregular, but there was a remarkable similarity between them and the curves obtained by Boscha and Brzesowsky (*ibid*). On estate A at 600 ft. the temperature of the leaf increased from 80·2°F. to 87°F. in $2\frac{1}{4}$ hours; on estate O at 3,600 ft., the temperature increased from 73°F, to 80·6°F. in 3 hours; while on estate U at 4,500 ft. the temperature varied from 65·3°F. to 77·5°F. in 3 hours. Twenty estates were investigated and as a result of this work he divided them into four groups and constructed hypothetical curves for temperature changes in fermenting leaf at various elevations. It will be seen from the

examples given that the period of fermentation does vary with the temperature, and although the theoretical temperature curves are not to be taken as the course of events at any particular elevation, it is suggested that they may help estates in determining the period of fermentation necessary in their locality. In his Handbook of Tea Manufacture (*Handleiding v.d. Thee bereiding*, 1922.) Deuss recommends that the fermentation should be followed by taking the temperature of the leaf every 15 minutes, when it will be seen that the temperature of the leaf rises to a maximum, and it is stated that the best time to dry the leaf is generally 15 minutes after the maximum temperature is reached. Incidentally, the temperatures given for estates A, O and U illustrate the different temperature conditions under which fermentation is carried out at various elevations, and when this is realised it will be understood why fermentations varies from place to place.

Although a rise of temperature during fermentation is thus definitely recorded from India and Java, this is not always found to occur under Ceylon conditions. In a cool, well ventilated fermenting room the temperature change observed has been very small, and fermentation proceeded at the Tea Research Factory, at a time when very fine teas were produced, unaccompanied by any appreciable rise in temperature above that of the floor on which it fermented. A rise in temperature has been observed in other factories as will be seen from the following table.

Table III.

Temperatures observed in fermenting leaf in ºF.

Period of fermentation in minutes.	Estate A	Estate B	
		Temp. in leaf	Temp.of air
0	74·0º	73·0º	72·0º
15	—	74·0	72·0
30	75·0	75·0	72·0
45	76·0	76·0	72·0
60	—	76·0	73·0
75	—	76·0	73·0
90	76·5	77·0	74·0
120	76·5	—	—
165	76·4	—	—

The rise in temperature is therefore very much less than that recorded by Deuss, although normal fermentation appeared to have taken place and the teas produced were of required standard. It is possible that there is some heat production as in other countries, but that it is lost by conduction and radiation. The loss of heat must be very great when it is spread in a thin layer where there is a proper

movement of the air surrounding the leaf. This will be particularly so when fermentation is carried out on a concrete floor, and, since fermentation is carried out successfully under such conditions, it may be that the most suitable condition for fermentation is that which tends to prevent any temperature change in the leaf. If this is so, then a big rise in temperature in the leaf mass is an indication that the fermentation is not carried out under the best conditions possible. In this connection it is to be remarked that many planters prefer to ferment their leaf on the floor, and in so doing they use the coolest place in the factory and also attain the greatest loss of heat by conduction, since a concrete floor is generally one or two degrees cooler than the air a few feet above the floor.

From what has been said about the temperature change in the fermenting leaf it will be realised that there is no conclusive evidence that the increase in temperature is to be desired, and when this occurs, it may be an indication of unfavourable fermenting conditions. There is no question but that heat is developed during the process, and the problem is whether this heat should be conserved or dissipated. The solution of this problem depends on the question of the temperature at which the leaf should be kept during fermentation.

(b) *The temperature at which fermentation should be carried out.*—The beneficial effect of cooling on fermentation led Nanninga in Java to study the temperature conditions suitable for fermentation and a series of experiments was carried out in order to throw some light on this question. I have not been able to study the original papers, but a short account of this work appears in Neuville's *Technologie du The* and in *Meded. v.h. Proefstation v. Thee*, **1914**, **31**. Nanninga completely dried fresh tea leaf over lime in a desiccator and then moistened the powdered leaf with water. The wet powder was found to develop the brown colour and aroma of fermenting tea, and on analysis it appeared to have undergone all the changes which green leaf undergoes during fermentation. Heating the powder to 158°F. rendered it incapable of undergoing these changes and on heating the powder to 104°-113°F., the action was strongly retarded. If the temperature was below 68°F. then the fermentation was very slow or did not take place at all, but an active fermentation occurred between 68°F. and 86°F. These laboratory experiments were followed by factory investigations in which the leaf was fermented at different temperatures, the variation in temperature being conditioned by the thickness of spread. Thus in one set of experiments the leaf was put out to ferment under the following conditions.

(a) The leaf was spread in a layer 2 cms. thick. The temperature of the leaf remained constant at 75·2°F. for $2\frac{1}{2}$ hours during which the fermentation was carried out.

(b) The leaf was spread 8-9 cms. thick, the temperature in this series running from 75·2°F. to 78·8°F. during the first hour and to 80·6°F. within $3\frac{1}{2}$ hours which marked the end of the experiment.

(c) The leaf was placed 8-9 cms. thick on a warm receptacle (ajakan). The temperature increased from 77°F. to 86°F. in $3\frac{1}{2}$ hours which was the duration of the experiment.

At the end of each experiment the leaf was dried at a temperature of 192°F. to 201°F., and the resulting tea critically examined. The method may be criticised because varying the thickness of spreading introduces unknown factors, one of which is the effect of aeration on fermentation. It is impossible to avoid such complications when experiments are being carried out in factories where every factor can never be brought under proper control, but, in spite of this, Nanninga was able to draw certain very interesting conclusions. The infusion obtained from (a) was light in colour and rather green, while the liquors were also greenish showing the tea to be under-fermented. The infusion from (b) was light and still somewhat green, but the liquor was dark and highly coloured although tinted with green. The development of aroma was more pronounced in (b) than in the others, and this experiment produced the best tea in spite of a long fermentation. The tea made from (c) was over-fermented, the infusion being much darker in colour than the others.

In the next series of experiments the period of fermentation was subjected to a greater variation as will be seen from the following data relating to the experiments:—

Table IV.

General conditions of Nanninga's Fermentation Experiments.

Series No.	Duration in hours.	Temperature F.	Spreading
a	4	73·4-75·2	Fine layer
b	6	,, ,,	,,
c	8	,, -77·	,,
d	4	75·2-80·6	Thick layer
e	6	,, -82·4	,,
f	$3\frac{1}{2}$	,, -87·8	,,

The best result was obtained under conditions (b), although the 8-hour fermentation in (c) did not appear to result in over-fermentation. The tea made in 6 hours (b), however, was superior in strength of liquor and aroma, and was much better than (f) which was made under the usual estate conditions. A better fermentation is thus obtained with a fairly long fermentation at a low temperature than in a shorter period at a high temperature. The experiments also show that an improvement on estate practice can be carried out by paying attention to the temperature of fermentation.

In the third series of experiments an attempt was made to ferment the leaf in the sun outside the factory, but a peculiar taint developed in the tea, and the conclusion was arrived at that fermentation in the open air was not feasible.

The former experiments were carried out at a fairly high elevation, but the fourth series were carried out on an estate at about 1,500 ft., and the results obtained supported the former conclusion that a relatively long fermentation at a comparatively low temperature gave the best results. The most suitable condition found in these experiments was a fermentation of 4 hours at 78·8°F.-80·6°F.

The final set of experiments was carried out at an elevation of 1,100 ft., low temperature conditions being obtained by means of a refrigerator. The temperature range varied from 57·2°F. to 97°F. but the tea fermented at the lowest temperature was still green after 2 hours, and only tinted with brown after 4 hours. Although it was difficult to decide which of the teas fermented between 68°F. and 77°F. was the best, there was no doubt that the tea fermented at the higher temperature of over 86°F. was inferior in quality.

The conclusions arrived at were:—

(1) Fermentation is very slow at low temperatures.

(2) Fermentation above 86°F. is bad, especially if the spread is thick, as the aroma developed is not pure.

(3) Too long a fermentation at low temperatures (below 68°F.) is harmful to the aroma which becomes less pronounced.

(4) When high temperatures are met with it is advisable to instal some arrangement by means of which the temperature may be maintained around 77°F., which is the most suitable temperature.

Mann (*The Fermentation of Tea*, Pt. I, 1906) also carried out experiments on the effect of temperature on fermentation, and came to the conclusion that the temperature of the fermenting room must be kept down to 82°F. The effect of high temperature on the amount of soluble extract in the made tea is clearly shown in his results. In one experiment the percentage soluble matter in tea fermented for 4 hours at 87°F. was 36·17 and the percentage tannin was 12·94, whereas the tea fermented for the same period at 113°F. gave 30·93 per cent. soluble extract and 8·27 per cent. tannin. Such a high temperature would represent an extreme and unlikely condition, but serves well to show in what way increase of temperature affects the resulting tea, and according to Mann a second action comes into play as soon as the temperature exceeds 82°F. This action is independent of the presence of any enzyme and it gives rise to insoluble, dark brown products, resulting in loss of pungency,

colour and body in the liquors. This effect is slight up to 84°-85°F. but is very marked at 90°F., and the most suitable temperature for fermentation is 82°F. or below.

On comparing the conclusions of these two investigators, it will be found that they are in close agreement, although Mann did not determine the lowest temperature suitable. They agree that temperatures above 85°-86°F. are unsuitable, but the temperature recommended by them for carrying out the fermentation is higher than that at which the process is successfully carried out on up-country estates in Ceylon.

Carpenter and Harrison (*The Manufacture of Tea in North-East India*, 1927) state that 82°F. is a practical maximum room temperature for average gardens in the plains during Monsoon weather but lower temperatures are better if they can be obtained, and Deuss (*Handleiding v.d. Thee bereiding*, 1922) who advises a temperature of 68°F.-77°F. thus modifies Nanninga's conclusion by extending the suitable temperature range to lower temperatures, and this is more in keeping with our experience in Ceylon. This temperature is aimed at in the fermenting rooms in Java, and it is customary on some of the estates at high elevations to warm their fermenting rooms when the temperatures are low (See *Tea Quarterly*, 1930, 3, 34), while warm fermenting rooms are cooled by some suitable scheme of humidification.

The evidence gained from these investigations agree with practical experience that a high temperature is detrimental to a proper fermentation, but this critical temperature of 85°-86°F. appears at first sight to allow a wide margin of safety, at least for up-country estates, where the temperature of the rolling and fermenting rooms may be from 70°-75°F. It is true enough that the leaf sifted out and spread for fermentation is doing this at a low temperature but it has been long accepted as a fact that a big proportion of the fermentation takes place in the rollers, especially in the later dhools. In spite of this little attention has been paid to what it means, and how we should adjust our policy to this altered viewpoint. In the first place, it is very evident that there is no *one* temperature of fermentation adopted in practice; the leaf spread on the fermenting table is fermenting at one temperature while the leaf in the rollers is fermenting at a higher temperature, which is very often considerably higher than the highest temperature advocated by Nanninga, Mann and Deuss. The difference in temperature between the leaf fermenting on the floor and the leaf fermenting in the rollers can be seen from the data already given for the Tea Research Factory in connection with the development of heat. There, the leaf on the floor was fermenting at 73°F. while the leaf in the rollers was fermenting at

84°-88°F., and I have seen factories where considerable ingenuity was spent in keeping cool the leaf on the fermenting tables, but where the rolling was carried out in such a way that the rolled leaf left the rollers in compressed flat cakes whose temperature I judged to be between 95°F. and 100°F. It must, therefore, be concluded that either tea fermentation allows a good deal of latitude in the temperature range suitable for its proper accomplishment, or else, one or other or both of these fermenting conditions is incorrect. It may be stated that when the temperature in the rollers rises above 85°-86°F., then the high temperature fermentation condemned by all the investigators comes into play, and if the leaf is maintained at this temperature for any length of time a loss of quality will be the result. It will be seen, therefore, that it is necessary to watch the temperature of the leaf in the rollers carefully, and to do everything to keep it down. This can be done by having a cool, humid rolling room, efficient roll-breaking, short rolls, and periodic application of pressure. I do not think it is quite realised how much humidification tends to improve conditions during rolling by maintaining a low temperature, and making it possible to have proper cooling of the leaf during the sifting, thus counteracting the effect of high temperature in the rollers. On referring to the figures given by Deuss for the heat production in fermenting tea, it will be seen that there is a tendency for the effect to be greater at the higher temperature. This is a natural consequence of the acceleration of the reactions by heat, so that in warm factories the fermentation initiated in the roller proceeds more rapidly than in a cool factory and results in a more rapid evolution of heat. Heavy rolling in so far as it bruises more cells in a shorter period of time thus increases the mass of material undergoing oxidation and augments the heat production. This is a well-known fact which most teamakers have had to adjust by rule of thumb and explains the benefit obtained from short rolls and periodic application of pressure. In this way the leaf is cooled by lifting up the pressure cap, and fresh leaf sap brought into action gradually during the whole of the rolling period. A cool atmosphere in the rolling room will materially help these expedients to keep the temperature of the leaf down, but full advantage of the cooling effect can only be obtained by careful roll-breaking.

Although Nanninga's work indicates a limit of low temperature at which fermentation can be carried out, the evidence is not very definite as to what is the lowest suitable temperature. If Deuss' limit of 68°F. is correct then the present tendency of fermenting and rolling in the same room is not always the best system. It is quite true that the coolest possible conditions are required for rolling in order to prevent the temperature of the rolled leaf going above 85°F., but in attaining this the temperature of the rolling room may be

reduced below 68°F., which is said to be too low for fermentation. Extreme temperature conditions of this kind may be met with up-country during the coolest months when the cold morning temperatures are ideal for rolling as the leaf does not get too hot during the process, but the fermentation of the leaves on the table is very slow and, according to Deuss, could be improved by a proper temperature adjustment. This can only be carried out when the rolling and fermenting rooms are separate units. The fermentation of the leaf is thus habitually carried out at two temperatures and it is difficult to decide what is the best temperature to aim at. It is hardly possible that the best temperature will be the same on every estate but it should be possible to determine a practical working range, the actual temperature within the range varying according to the quality of the leaf, fineness of plucking and degree of wither.

(*To be continued.*)

TRICHOGRAMMA; AN EGG PARASITE.

C. B. REDMAN KING.

INTRODUCTION.

The aim of biological control is to alter the existing equilibrium between a pest and its enemies in favour of the latter, so that the damage done by the former shall be reduced to or below what may be described as the economic minimum. It may be carried out in two ways:—

(1) By the introduction of a suitable enemy into a region not formerly occupied by it; as an instance, a pest introduced accidentally into a region may be successfully countered by the further introduction of an enemy or enemies from the country of origin.

(2) By the artificial propagation of an enemy so that it can be liberated in large numbers *at the appropriate time*.

The two methods differ radically in one respect. In the first case, a foreign enemy is introduced which it is hoped will propagate itself in the new conditions and produce a natural balance between itself and the pest. In the second case, the enemy may already be indigenous, but does not exert a control, owing to some factor or factors which allows the pest to increase rapidly before the parasite has been able to attack in any numbers. In this case, artificial mass production is designed to throw into the field a large number of the enemies of the pest at a time when the pest is about to begin its campaign. It is into this category that Trichogramma falls.

THE NATURE OF TRICHOGRAMMA

There are several species in this genus, all very much alike. They are minute insects, less than a millimetre in length and belong to the order Hymenoptera, to which bees and wasps also belong. Numerous forms in this order make a speciality of parasitism, and it may be noted in passing that both the caterpillars and pupae of Tortrix are parasitised to some extent by several members of this group. Trichogramma, however, differs from the others, in that it attacks the eggs by piercing them with its ovipositor and laying an egg of its own in each egg, so that the parasite develops at the expense of the Tortrix embryo. This is obviously satisfactory from an economic standpoint, since the pest will be destroyed before it has done any damage.

The species which has been most studied is *T. minutum*, on which work has been carried out for a number of years. To quote S. E. Flanders, "The hosts of this parasite . . . number well over one hundred and fifty species in the orders Lepidoptera, Coleoptera,

Hymenoptera, Neuroptera, Diptera and Hemiptera. It has been known to attempt oviposition in the juice globules of Okra plants, the swollen abdomen of the mite Pediculoides, and in paper smeared with the hair covering of the egg-masses of the Browntail moth. The majority of hosts, however, are Lepidoptera, and its oviposition is confined to eggs deposited on exposed surfaces and without a protective covering of a hard, hairy, or sticky substance. A Hymenopterous host is recorded as having the highest number of individuals developing from a single egg. In Wisconsin, thirty pupae were found developing in a single egg of *Cimbex americana*."

MASS PRODUCTION.

The adaptability of this parasite has enabled it to be used for extensive propagation under laboratory conditions, but it is only within the last four years that attempts to raise it on a large scale have been undertaken, and a million a day figure only reached within the last two, in America.

Our indigenous species, *Trichogramma erosicornis*, has not so far shown the remarkable adaptability of *T. minutum*. It has been bred for several generations on the egg of the flour moth, *Corcyra cephalonica*, but the results are extremely variable. It will be necessary to obtain a regular ninety per cent. parasitism before it can be considered enough for mass production purposes. It is hoped to obtain some specimens of *T. minutum* later on for comparative purposes; and it is interesting to note that several of this species were obtained in America in 1926 from the eggs of a Tortrix moth, which were afterwards developed on mass production lines.

GREEN MANURING.

(REVIEW)

In the current number of *Tropical Agriculture* (March 1930) H. G. Mundy, Chief Government Agriculturist, Southern Rhodesia, contributes a paper on experiences with various forms of green manuring in his administrative area. The writer is chiefly engaged in the cultivation of maize and consequently the adequate use of green stuff is rendered more simple in procedure than in the case of permanent crops such as tea. Notwithstanding the differences between Rhodesian and Ceylon conditions, his main conclusions cannot but be of interest to all tropical agriculturists.

The proved value of green manuring in an intensive form is indicated by two items of information in this paper. The first is that at a recent meeting of the S. Rhodesian Maize Association, representing more than 1,000 farmers, a resolution was carried to the effect that it was unnecessary for the Government to demonstrate further the advantages of regular green manuring, since every producer in the country had become firmly convinced of this. The other is that farmers are willing to sacrifice every fourth crop in order to grow green manures, usually Sunn Hemp (*Crotalaria juncea*) and velvet Beans (*Stizolobium spp.*)

The author deals with the many advantages of green stuff, both as preventing soil erosion and conserving fertility, which have been emphasized by the writer of this review and others in the pages of the *Tea Quarterly*, and in support of these views he quotes a number of interesting facts.

At the Central Experiment Farm, Ottawa, Canada, nine years' consecutive growth and ploughing in of red clover were found to have increased the nitrogen content of the soil by 473 lb. per acre. Even if under tropical conditions, which are less favourable for nitrogen retention, an appreciable discount has to be allowed, such a result still shows the tremendous potentialities of green manuring in soil recuperation. Of special interest from the nutritional point of view is the report that carefully planned investigations in S. Rhodesia, supported by the testimony of leading planters and farmers, indicate that in the absence of a sufficiency of humus, artificial fertilisers are powerless to exert their best and most remunerative effect. It is widely recognised in the Colony that the application of fertilisers to a soil deficient in organic matter is mere waste of time and money. A previous article in this number of the journal on the Institute's field programme for the ensuing year describes a projected experiment which should throw some light on the application of this principle to Ceylon conditions.

In Rhodesia a great deal of work has been done on the question of management and cultivation of soils under green manures on lines allied to those outlined in the cover crop section of the aforementioned field programme. From this work the important point has emerged that a further cultivation subsequent to the actual incorporation of the green manure has markedly beneficial effects. This is attributed to the better distribution of the humus that such cultivation ensues. The reviewer hazards the opinion that better conditions of aeration and decomposition also help.

In Rhodesia no instances of green manuring causing toxicity have been recorded, even in the cases of citrus orchards which are given an annual treatment.

There is no necessity to reproduce the anti-soil erosion arguments which Mundy's paper details, but one point is specially noteworthy. The author states that "green manuring will be of little benefit unless accompanied by adequate measures to control soil erosion. For if not, the improvement in fertility effected by green manuring will quickly be neutralised by the washing away of the improved surface soil." As a text for a discourse on the relative merits of ground cover and green manuring involving clean weeding as usually understood, this quotation could not be bettered.

T. EDEN

Agricultural Chemist.

QUARTERLY REPORT ON THE WORK OF THE SCIENTIFIC STAFF, TEA RESEARCH INSTITUTE.

Dr. Gadd returned from leave and resumed his duties as Mycologist on February 3rd. During the period under review thirty consignments of diseased plants were received for examination in the mycological section while the Mycologist visited four estates in the Ambawella, Uda Pussellawa, Lindula and Norwood districts. Of the specimens received 22 were tea, 2 Dadap, 1 *Crotalaria usaramoensis*, 1 Gliricidia, 2 Acacia and 2 *Tephrosia vogelli*.

Experiments have been carried out by the Mycologist to determine which, if any, of the fungi isolated from wood rot of tea were capable of causing a decay of tea wood under controlled conditions. Fourteen fungi were tested, of which 8 had been isolated from tea wood rot. The others used were *Poria hypolateritia*, *Rosellinia arcuta*, *Armillaria fuscipes*, *Rhizoctonia bataticola*, *Fomes lucidus* and *Irpex destruens*. The first three named are known to cause root diseases accompanied by a wood rot, whereas the two last-named have been suggested as common causes of wood rot.

The experiments proved that Poria, Rosellinia, Armillaria and Irpex caused distinctive rots of tea wood, and that of the fungi isolated from wood rot of tea only one, an unidentified species (Cult. No. 23), proved to be capable of rotting the wood under the conditions of the experiment. Negative results must, however, be regarded as inconclusive.

Investigations have also begun on a disease of Acacia trees which results in their death. A fungus closely related to, if not identical with, *Aglaospora aculeata* has been isolated from the diseased roots. *A. aculeata* is recorded as a stem disease of tea, but inoculation experiments are necessary before conclusions can be drawn concerning its parasitism to Acacia. Further investigations are required as to its parasitism to tea as, in the wood-rotting experiment referred to above, this fungus failed to produce a definite rot though it is commonly associated with a definite rot in the field.

Eelworm and *Poria hypolateritia* have been found to cause diseases of *Tephrosia vogelli*.

In the Entomological Section enquiries have related chiefly to Tortrix, Nettle Grub, Shot-hole Borer, Red Borer, Helopeltis, Brown and Green Bugs, White Grub, Bagworms, Weevils and all five species of Mites.

Work on the breeding of Trichogramma has continued to occupy most of the Entomologist's time. Attention has in the first place been directed to increasing the supply of eggs used for parasitisation. Measures were taken to develop the stock of grain moths, and by the end of March there was a daily outturn of 4,000 eggs. Most of these were put back into the grain, as it is considered absolutely necessary to continue to increase the supply. It is mainly upon an abundant supply of eggs that success in liberating a large quantity of parasites depends. While the eggs of *Corcyra cephalonica* are the ones chiefly used, those of *Sitotroga cerealella* are occasionally employed as it is considered advisable to keep this strain going as well.

The behaviour of the parasite has been disappointing. It varies remarkably in its desire or ability to parasitise eggs under apparently the same conditions, in spite of the utmost encouragement. In this respect it differs considerably from another species which behaves much more according to plan and which will, moreover, parasitise any egg that is big enough, as long as it can pierce the shell with its ovipositor. It is hoped that a consignment of these will shortly be received.

In addition to the above work on Tortrix, arrangements were made by the Entomologist for an investigation on Nettle Grub. Work on this pest has now been made possible by the temporary appointment of another Assistant in the Entomological Section. This Assistant will be stationed in the Uva district, accommodation having kindly been provided by Gonakelle Estate.

The Uniformity Trial carried out by the Agricultural Chemist on Scrubbs Estate was brought to a conclusion at the end of 1929 and the data, involving some 6,000 yield records, is now in process of statistical analysis. Important deductions can already be made from these results in regard to the magnitude of errors necessarily inherent with a crop such as tea, and the methods available for reducing such errors to a minimum. An interesting fact that emerges from this analysis of error is that probably the main factor militating against the reduction of such errors below a certain level is not so much soil heterogeneity or even bush variation as the difficulty in obtaining a definite standardisation of plucking. These results will have an important practical application in determining the lines on which the field experiments at St. Coombs will be laid down in the present year.

The Agricultural Chemist has also continued his study of the decomposition of Mana grass in the preparation of artificial farmyard manure by the Adco process. Decomposition in the experimental pit has been very satisfactory and from a physical point of view everything points to the production of a satisfactory manure. The

course of the decomposition has been followed stage by stage, and the figures obtained will throw considerable light on the losses of nitrogen or other constituents that occur during fermentation and storage and, it is hoped, indicate ways by which such losses may be minimised.

The Biochemist has been engaged in a study of the rolling process. It is obvious that before any systematic investigation of tea fermentation can be carried out more precise data must be obtained regarding the nature of the material obtained after each roll when different methods of rolling are adopted. In rolling, the leaf is twisted under pressure with the result that the leaf is crushed, sap is expressed and the leaf is broken up. During the roll-breaking and sifting the finer portions are removed from the coarse particles, the actual amount separated out depending on the type of rolling adopted and the care given to the roll-breaking. Not only does the amount depend on the rolling but the way in which the separated fractions are made up may also vary, *i.e.*, the pluck does not always break up in the same way so that the nature of the leaf put out to ferment after each roll varies according to the rolling programme, and is therefore a variable factor in the fermentation. This also controls the composition of the B.O.P. as this grade is generally taken from the first few dhools. The actual shearing effect of the rolling is a purely mechanical one and its effect is best measured in a mechanical way, that is, by examination of the leaf after rolling and separating out the various parts which can be isolated. Thus in one trial the sifting after each roll separated 10·1, 15·5, 22·0, 26·0, 19·6 per cent. leaving a big bulk of 6·8 per cent. of the total leaf rolled; while on another occasion the sifting produced 20·7, 17·3, 18·7, 25·8, 11·3, 6·3 per cent. Two rollings which were supposed to have been the same have therefore produced quite different effects. In the first, 47·6 per cent. of the leaf is put out to ferment under cool conditions after the first 3 rolls, whereas in the second, 56·7 per cent. of the leaf is put out to ferment after the third roll. The leaf being fermented thus differs in the two, and also B.O.P. is being drawn from a different mixture.

The manner in which the pluck breaks up during the rolling has been followed by picking out the stalks, tip, and leaf particles, and determining their dry weight.

Under controlled experimental conditions, this method of investigation will no doubt supply a good deal of useful information. The first dhool separated out, when no pressure is applied, consisted of broken bits of leaf, a good deal of stalk and golden coloured tips. When pressure is applied the percentage stalk falls off as well as the tip which shows up discoloured and is difficult to pick out from the

rest of the leaf. With light rolling the second dhool consists of very fine bits of leaf, stalk, which is in shorter pieces than found in the first dhool, and big sized tip. The tip is getting discoloured and does not show up so well as in the first dhool, so that by visual examination it appears to be present in less quantity than is really the case. With heavier rolling the tip is completely discoloured and unrecognisable from the rest. The third roll is also composed of fine leaf particles, some loose stalk, and a few discoloured tips, while at the fourth roll, when fairly heavy pressure is applied, the stalks begin to show up red and lacerated with several pieces of cuticle removed. Leaf midribs also begin to show up almost like stalk with the difference that they have ragged bits of leaf attached to them. Such pieces form the bulk of the fourth dhool. The remaining big bulk consists of long stalk varying from 2-4·5 cms. in length, and coarse particles of leaf. These leaves are generally cut across and show a very prominent midrib, while a good number of the stalks have the base of the bigger leaves attached to them. There will be slight variations from this at different places no doubt, but it is a fairly representative picture of what happens to the pluck in the rollers.

The Biochemist has also made an examination of the actual size of the particles separated in the various dhools by sifting the dried tea obtained after each roll and fractionating with a hand sieve. It is obvious from such a physical examination of the dhools that they are made up of different portions of the pluck, and when the sifted out portions were examined for extract content some interesting data were obtained. The most striking point is a sudden drop in extract found in the 4th and 5th dhools and the big bulk. Whether this is due to an actual difference in the original composition of the leaf particles composing these dhools, or to the fact that these fractions have undergone a stronger fermentation it is not possible to decide at present. The latter alternative appears to be the most likely as such a big difference is not found when rolling without any decided pressure. Of course, in that case a large proportion of the leaf which appears in the earlier dhools with heavy rolling is still left in the last two dhools, and this makes it difficult to compare the two.

These experiments were initiated with a view to testing out methods of investigating the rolling process and to find out what material would be obtained for fermentation experiments, as it would be useless to carry out fermentation experiments unless the material obtained was uniform at different times. In this way it is hoped to determine the conditions of rolling which will separate approximately the same fraction from the plucked shoots at each roll, and also correlate this with the actual grading afterwards obtained.

The Plant Physiologist arrived in Ceylon on March 3rd and his time since arrival has been chiefly occupied in equipping the temporary laboratory which has been provided for him in the factory and in the collection of material. His programme of work provides for a full study of the nutrition of the tea plant, data being obtained by the analysis of the various parts of pruned, plucked and control bushes at different stages of growth.

Attempts to establish clone stocks of tea for experimental purposes and an anatomical investigation of the reaction to pruning are also in hand.

ROLAND V. NORRIS.

Director.

NOTICES.

Plant Physiologist.—Mr. F. R. Tubbs, M.Sc. (Lond.), D.I.C., A.R.C.S., reported his arrival in Ceylon on the 3rd March, and is now stationed at St. Coombs.

Advisory Work.—Entomological enquiries should be addressed to Mr. C. B. Redman King at Mahagalla Bungalow, Norwood. Specimens sent by train should be consigned to Hatton Station c/o. Mr. H. E. Fernando, Forwarding Agent.

All other enquiries should be addressed to the Director, Tea Research Institute, Nuwara Eliya.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Superintendent may not be free to show them round. Such visitors on arrival at the Factory are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the Matakelle turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

ROLAND V. NORRIS.

Director.

EDITORIAL.

T. R. I. CONFERENCE.

The Second Conference of the Tea Research Institute will take place at St. Coombs in February next year, the 26th and 27th of that month having been provisionally fixed as the most convenient dates. Further details regarding the Conference will be given in the next number of *The Tea Quarterly*, and District Associations will also be informed of all arrangements made.

While it will not be possible to arrange sleeping accommodation at St. Coombs, such accommodation will be available in Hatton and Nuwara Eliya, both within easy reach, and the times for the meetings will be arranged to meet the convenience of visitors staying at these centres. Lunch and tea will be obtainable at St. Coombs.

TEA DISEASE IN NYASALAND.

Reports have been received of what appears to be a new disease of tea in Nyasaland. The disease is said to manifest itself by a rapid yellowing of the leaves which in a few days turn from the normal green to an orange colour. The bush then withers and dies. No explanation of the origin of the disease is at present forthcoming nor is any information available regarding its treatment. It is, however, understood that a member of the staff of the Amani Institute is now in Nyasaland investigating the problem and a request has been made for fuller details.

UNHEALTHY SEEDLINGS.

From several estates reports have been received of a type of unhealthy seedlings in the nurseries and trouble of a similar kind has been experienced at St. Coombs. The seedlings seem to be free from any fungus or insect invasion but exhibit a generally unhealthy appearance with a yellowing of the leaves. In more marked cases the leaves wither and fall off and the seedlings may die back to ground level. The roots on the contrary appear healthy and bear numerous laterals. In general, these symptoms tend to appear about the time the seed food reserves become exhausted. No apparent dearth of carbohydrate or fats was however found in specimens examined by the Plant Physiologist. A notable feature of the trouble is its distribution. At St. Coombs it has been most severe on the higher portions of the seed beds which slope upwards from swamp level. An examination of the soil showed a transition from a high humus content and a moisture content of 45·2 per cent in a healthy area to a lower humus content and moisture percentage of 19·2 in the area most affected. No differences in soil reaction were noticeable. Manurial treatment carried out by the Agricultural Chemist, both in the field and in pots

to which diseased seedlings had been transferred, gave no positive results. With the onset of the monsoon the less severely affected plants have improved considerably, irrespective of any other treatment given, and some of those which had died back to ground level produced fresh shoots, but it is unlikely that these will develop into good plants within a reasonable time. The trouble would appear to be largely concerned with the water supply. The soil in the area most affected is light and dries out very rapidly with a tendency to cake instead of forming a mulch. In such circumstances artificial top watering would be relatively inefficient.

Similar conditions to those described have been produced in older tea seedlings by the Plant Physiologist by removal of the lateral roots which results in cutting off the water and salts supply.

NETTLE GRUB.

In connection with the investigation of Nettle Grub, it will be of considerable assistance if estates in areas liable to infection will report, monthly if possible, the presence or absence of Nettle Grub. If the grubs are present it is asked that collections of these may be sent to Gonakelle for examination. Such collections will furnish information (1) as to the direction in which the pest is spreading; (2) the distribution of various species; and (3) the presence or absence of parasites.

Reports and specimens may kindly be sent direct to Mr. G. D. Austin, Gonakelle Estate, Passara.

ACKNOWLEDGMENT.

In response to the appeal made for details regarding experiments on cover crops, manufacture, etc., carried out by planters, a number of replies have been received giving information of much interest and value. The Director wishes to thank those who have responded in this way.

A REVERSE SLOPE DRAINING SYSTEM.

A. G. D. BAGOT.

The Tea Quarterly for February 1930 emphasized certain principles in the laying out of drains as preventatives of soil erosion. Chief among these were the following:—

(1) It is known that the open drain with a gradient of 1 in 30 allows the majority of the silt and loam to be lost unless the velocity of the running stream can be arrested.

(2) The retention and percolation of water bring great benefit to the soil since rain water contains dissolved oxygen which renovates the soil atmosphere. The distribution of this dissolved oxygen constitutes one of the major methods of securing soil aeration, particularly for sub-soils.

(3) Trapped air in the soil capillaries is one of the most formidable barriers to water absorption.

Starting from these principles, the writer has been experimenting with a system of drainage which aims at embodying these points and which has the advantage that it can be readily constructed from existing drains. The results so far obtained seem to be of sufficient interest to warrant their being placed on record.

METHOD OF CONVERSION.

The special feature of the system is the provision of terraces or steps in the existing drains, these being cut so that the tread of the steps has a *reverse* slope which acts as an immobiliser of running water.

Starting at the highest point of the existing drain, a hole 6 ins. in depth is cut. With a road tracer set level, the point where this new level re-appears at the drain bottom is found. From this point the drain bottom is cut back giving a regular slope at such an angle that at the starting point the depth is 1 ft. 6 ins. below the original drain bottom, or 1 foot below the set off from the road tracer hole. Reference to the diagram shows the manner of working. The operation is then repeated and a new section is cut, and so on down the slope of the drain.

The length of the terrace is determined by the gradient of the original drain, and in the case of a 1 in 30 drain is 15 feet. With a drain width of 1 ft. 6 ins., each section will hold 11·25 cubic feet of water before overflowing, so that the cubic water holding capacity of 100 ft. of drain will be 75 cubic feet. Provided that the deep end of the terrace is 1 ft. 6 ins. below the drain bottom and that levelling is done at the 6 ins. depth, the cubic capacity of the drains is constant at all gradients, but the terrace length decreases with gradient and the

number increases. That this is so can easily be seen by means of the following calculation. The cubic contents of a 100 ft. drain equals $\frac{100}{A} \times B$, where A is the length of terrace, $\frac{100}{A}$ the number of terraces possible, and B the capacity of an individual terrace.

$$B = \tfrac{1}{2}\ (A \times 1{\cdot}5 \times 1), \text{ so that}$$

$$\text{Capacity} = \frac{100}{A} \times \tfrac{1}{2}\ (A \times 1{\cdot}5 \times 1)$$

$$= 100 \times 1{\cdot}5 \times \tfrac{1}{2} = 75, \text{ since A cancels out.}$$

The importance of this is that the length of terrace can be adjusted to meet practical requirements without decreasing the effective capacity.

Soils vary enormously in their capacity to hold water without water-logging, and in the rate of absorption of moisture. Therefore, as to when these drains overflow will depend upon the soil in which they are cut.

The holding capacity of these drains can be appreciably increased by deepening or widening by a few inches. Reference to the diagram shows that the capacity can be increased from 75 cubic feet to 93, or 131 cubic feet per 100 ft. of drain by making the steps respectively 21 ins. and 27 ins. instead of 18 ins. deep.

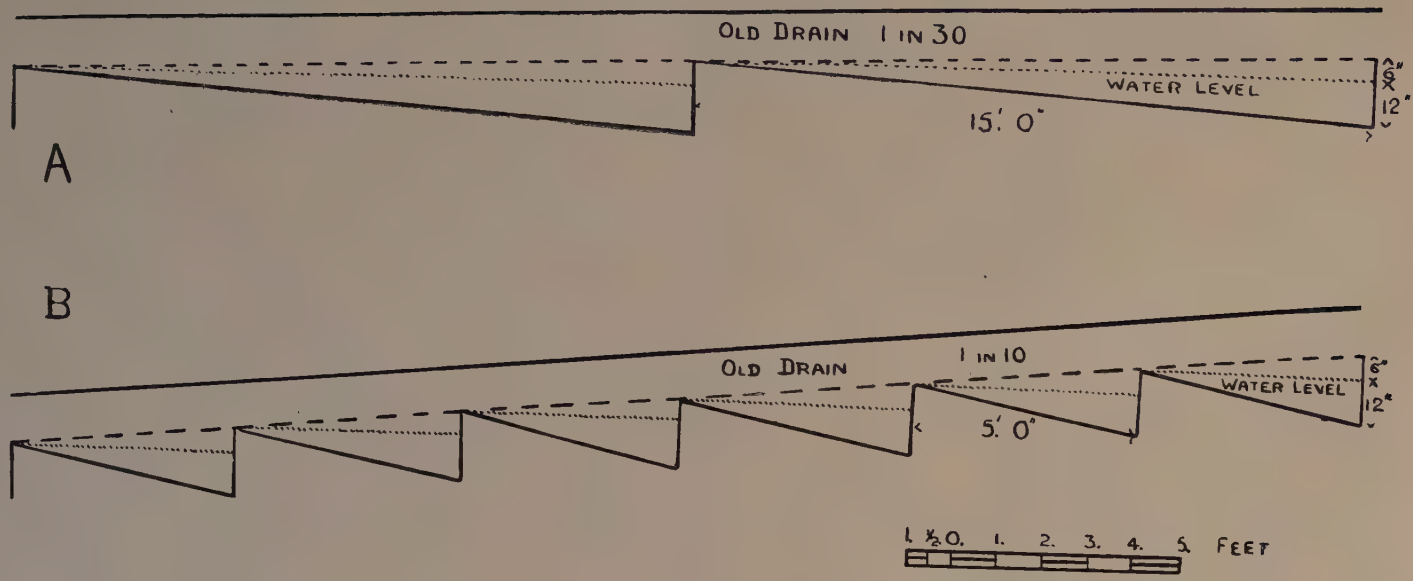
What is the optimum length ? This can best be decided after consideration of the advantages of the system.

ADVANTAGES OF THE SYSTEM.

The effect of the terraces is clearly to break the continuous flow of water, thus allowing the suspended soil to settle. At the bottom of each spill there is necessarily a centre of disturbance, but ahead of this a bank of silt forms which adds to the effectiveness of the system by forming a supplementary barrier. In operation this silt bank seems to act as a filter, allowing surplus water to pass through and over the spill, but retaining solid material, so that even when the spills are operating the water runs over remarkably free of turbidity. The construction of the whole system minimises any head of water and undoubtedly this also plays a large part in ensuring success. Further, the system presents a slightly larger absorptive surface than the parent drain and the steps provide an outlet for trapped air which can make its way out under the pressure of the accumulated water. Having stopped the major portion of the direct flow, the water is kept on the land as sub-soil water. The system therefore conforms to the basic principles set out above.

In the light of the foregoing, it is seen that too long a terrace decreases the number of possible air escapes, too short a one brings the spill disturbance from one spill near to the next spill and may defeat the whole aim of the system. 15 feet appears in practice to be an optimum length and avoids both disadvantages.

PLATE I.



Old Drains converted into Reverse Slope Drains.
The cubic water-holding capacities of A and B are equal.

As previously stated, the length of the terrace is determined by the gradient of the original drain, in the case of existing drains being converted; but in a new clearing they can be made at such a gradient as to obtain a length of 12 to 15 feet. When tracing new drains the gradient may be varied to avoid any obstruction without impairing the effective capacity.

Existing drains can be converted at small cost since the work entailed is equivalent to deepening them by an average of 9 inches, whereas new drains may be cut to an average depth of only 1 foot.

The upkeep is not appreciably more than is at present spent on keeping drains clean, since the silt is deposited along the whole length of the drain, not as in a silt-pit where the silt along the drains has been accumulated into pits cut at intervals along the drain.

THE SYSTEM IN OPERATION.

It has been possible to a small extent to check up the actual performance of this system since its inception and to confirm the efficacy that has been deduced from general considerations.

The first severe test occurred on the nights of May 5th-6th when the rain-gauge registered a fall of 8 inches of rain on the estate. At 6 a.m. on the 6th the system was operating normally without overflow, and the high water marks of debris indicated that in the majority of terraces no direct overflow had occurred. The lightness of the soil on this particular area undoubtedly helped, but nevertheless it was a severe test. On one portion of the area, the terraced drain was fed from an unterraced section, and immediately above the terracing an ordinary silt-pit was located. This silt-pit was nearly full of silt, and turbid water was passing over it on to the terraces. At the end of the terracing, although water was passing over the spills (by reason of the unchecked supply from the ordinary drain) the flow was only very slightly discoloured. This section of the ordinary drain has now been cut to the reverse slope type with the result that the above-mentioned silt-pit now remains comparatively empty.

In one case where this system had been established in a 1 in 30 drain of 16 ins. width, 2·26 inches of rain fell in $1\frac{1}{2}$ hours. Even in this case the spills did not overflow. The explanation of this fact would appear to be due to the principle of the system as well as the rate of absorption due to the particular soil. In the first place, some of the water entering the new drain from the commencement of rain is being absorbed, since its initial flow is prevented. For instance, the first $\frac{1}{4}$ inch of rain falling is directly absorbed into the drain, and while the remainder of the water is merely finding its own level in each section, it is at the same time being absorbed at a steady rate, which in this case was capable of preventing these drains from overflowing.

The system is still under observation, but its usefulness seems to be already assured. It can be carried out without stone, although a flat paving stone at the spill is an advantage so as to prevent erosion of the step, should this be found necessary in districts where exceptionally heavy plumps of rain are experienced. But, in practice, since the overflow is merely caused by the displacement of water in each section, no rapid stream is formed to cause any appreciable erosion on the lip of each section.

TEA FERMENTATION.—Part III.

D. I. EVANS.

HUMIDITY AND ITS IMPORTANCE FOR FERMENTATION.

(a) *What is meant by the humidity of the atmosphere.*—The question of humidity has already been dealt with in *The Tea Quarterly* 1929, 3, but I may be excused for recapitulating to a certain extent what will be found more fully dealt with in the former articles. Air at any particular temperature has the property which enables it to take up a definite amount of water in the form of water vapour. If the air contains its full complement of water vapour at any particular temperature it is said to be saturated with water vapour at that temperature, but if it does not contain the maximum amount of water vapour it is capable of taking up, then on exposing any water surface to such an atmosphere some of the water can evaporate into this air at that temperature. The water surface may be a wet fabric or wet leaf, and rolled tea leaf put out to ferment is such a wet surface owing to the water in the expressed sap. Air which is not saturated with moisture can remove water from such bodies and this results in a drying effect. The drying power of the air is determined by the difference between the actual amount of water vapour present and the total amount of water vapour it can hold when saturated at that temperature, as well as upon the rate at which the air moves over the substances to be dried. It is therefore important that we should be able to measure the relative wetness or dryness of the air, *i.e.*, its humidity must be known. When the humidity is high, the air has a low drying power, but when it is low the air acts as a drying agent.

(b) *Measurement of Humidity.*—The humidity of the air is generally determined in practice by observing the difference in the temperatures recorded by wet and dry bulb thermometers lying alongside each other. When the wet and dry bulb thermometers read the same there is no evaporation from the wet bulb, which shows that the air in contact with the thermometer is saturated with moisture. If the temperature recorded by the two thermometers is different, then

moisture is evaporating from the surface of the wet medium on the bulb of the thermometer, which shows that the air is not saturated with regard to water vapour. In other words this air causes a drying effect on the muslin. The greater the difference between the two thermometers, the greater the drying capacity of the air, so that by observing the differences between the readings of a wet and dry bulb thermometer, we can learn how wet bodies exposed to this air will behave, and by referring to hygrometric tables it is possible to determine exactly how much moisture a certain volume of air can take up. For the present it is sufficient to know that when the wet and dry bulb thermometers record the same temperature the atmosphere is saturated with water vapour and has no drying effect. If there is a difference between the dry and wet bulb thermometers, then the air can take up water from the moist surfaces and this results in the drying out of the substances. The greater the difference between the wet and dry bulb the greater is the drying capacity of the air, but it is not possible to gauge what this difference is in any way except by the use of a scientific instrument such as a hygrometer consisting of wet and dry bulb thermometers.

(c) *Effect of the air humidity on fermentation.*—The investigations dealing with the temperature relations during fermentation were discussed in the previous article, but only a passing reference was then made to the effect of humidity on fermentation and the way this air property is bound up with the temperature control of the rolling and fermenting rooms. When the temperature effect on fermentation was being studied, it was found that the humidity of the air played an important part in fermentation. It was pointed out years ago by Bamber, Mann and others that it was necessary to maintain a humid atmosphere in contact with the fermenting leaf. Mann (*Factors which determine the quality of tea*, 1907, 4) states that "the atmosphere should be saturated with moisture, as any drying of the leaf which occurs during fermentation damages the resulting tea, causing oxidation of the tannin, etc., to go too far." Deuss (*Meded. v.h. Proefstation v. Thee*, 1917, 52.) found that a dry atmosphere in the fermenting room resulted in a very uneven fermentation, and the leaf blackened instead of becoming nicely coloured. This blackening effect is due to the drying action of the air in contact with the leaf, and it is particularly noticed if there are any draughts playing on the leaf. Deuss also condemns the practice of countering this drying effect by turning over the leaf mass, because this only results in the formation of a new surface thus facilitating further drying. He also found that it was possible to determine the drying effect quantitatively. When this was done it was found that the drying effect of a dry atmosphere was greater than seemed possible at first sight. A loss of 3 to 4 per cent was quite usual, and this did not seem to matter, but a loss of

10 to 15 per cent was not uncommon. A loss of this nature was decidedly harmful, resulting in an uneven fermentation giving dull infusions and liquors. Deuss advised that the atmosphere surrounding the leaf during fermentation should be saturated or at least be within 95 to 98 per cent of saturation, but in a later publication (*Handleiding v.d. Thee Bereiding*, 1922), he advocates 90-95 per cent saturation at a temperature of 68°-77°F. This demands that the difference between the wet and dry bulb thermometers exposed to this atmosphere should be 1°F. Carpenter and Harrison (*The Manufacture of Tea in North-East India*, 1927.) state that a humid atmosphere helps in the production of reddish substances in the fermenting leaf, but a dry atmosphere results in the production of dark-brown substances. They say it is necessary to prevent the formation of these tannin-brown bodies if good colours are to be obtained in the liquors and in the infused leaf, and according to these authors the most important factor in fermentation is the humidity, which should be as near 95 per cent as possible. Harler (*Quart. Journ. Ind. Tea Assoc.*, 1929, 11.) again stresses the same point, and adds that a high degree of humidity is very necessary for a proper fermentation when the rolling and fermenting room temperatures are high, but on the other hand the humidity must not be so high as to result in any deposition of moisture on the fermenting leaf.

All the investigators of the problems of tea manufacture thus agree as to the necessity of maintaining a humid atmosphere in contact with the fermenting leaf, and this has to a certain extent been recognised to be true by the industry for a long time. However, the methods employed to combat a dry atmosphere during the hot months were only half-hearted until recent years, but where the importance of a high humidity has been realised and advantage taken of modern methods of producing a high humidity, the results obtained have been very gratifying. There are very few factories in Ceylon which do not require some means of producing a humid condition some time or other during the year, but the argument is put forward that the best teas are produced during the dry months when the atmosphere in the rolling and fermenting rooms is very dry indeed. The quality of the tea during these periods, however, depends on the good quality leaf which is coming into the factory for manufacture and ideal conditions for withering, and is not a result of a dry atmosphere for fermentation. The latter condition militates against the possibility of making the most out of a good quality leaf and of thus producing the best tea possible from the material at one's disposal. Even during the wet months of the year there are many days when the humidity is low during certain periods of the day, and although the drying effect produced during this short period may be small, it all tends to make for less uniformity in the tea.

(d) *Maintenance of high humidity.*—The first attempts at maintaining a high humidity were not very satisfactory, estates in general being content with hanging a few wet cloths around the walls of the fermenting room, allowing a gentle flow of water to run down the walls, or covering the fermenting leaf with a wet cloth. These cloths were very difficult to keep clean, especially where the practice of covering the fermenting leaf with wet cloths was adopted. Again the wet cloths hanging along the walls, etc., sometimes hindered the proper aeration of the room, resulting in a close, stagnant atmosphere. This condition was ideal for the development of all kinds of moulds and bacteria, and it is really surprising that there were not more complaints of taints in the tea produced under such conditions. When this fault was recognised, the fermenting room and rolling room walls were pigeon-holed and water was allowed to flow down the walls. Ventilation was improved in this way and the incoming air, passing through the water stream, evaporated some of the water, became humidified, and cooled the room to a certain extent. These methods were considered satisfactory until actual measurements were taken of the humidity changes produced. When this was done it was found that these methods were very inefficient and could at times be harmful. The wet cloths did not maintain contact between the air and water for a sufficient time to produce the requisite degree of evaporation necessary for anything approaching the proper degree of humidity. If the cloths were duplicated the ventilation suffered and a heavy atmosphere was produced. Pigeon-holed walls with water running down them were also found to be unsatisfactory in increasing the humidity and these had the further disadvantage in that they often caused currents of hot, dry air to play on the fermenting leaf and increased the fault they were designed to eradicate.

The failure of such simple expedients has led to the adoption of certain humidifying plants, some of which have been successfully used in other industries, especially in the cotton factories of Lancashire and India. In Java they advocate the Sulzer Spray apparatus, and a particular installation marketed by the firm Assendelft de Coningh of Soekaboemi, while in North-East India they favour the Vortex system of Mather and Platt, Manchester. Harler (*Quart. Journ. Ind. Tea Assoc.*, 1929, 11.). Several systems are being developed and tried out in Ceylon with apparent success, but it is too early as yet to compare the relative merits of the various plants. Owing to the importance of this question and the possible extension of humidifying installations for warming fermenting rooms, it is proposed to collect as much information as possible of all existing plants and to study their efficiency in actual practice. A certain amount of co-operation on the part of the planting community will be necessary to this end, as it will be impossible to try out every type of installation at the Tea

Research Institute's Factory. Any information given will be gladly received and opportunities to inspect any plant in action will be most welcome.

FERMENTATION IN THE ROLLING ROOM.

It is now generally realised that the process of tea fermentation starts when the leaf is crushed in the rollers, and that some fermentation of the fine leaf occurs during the rolling, while the leaf persisting in the later rolls has almost completed its fermentation during the process. In view of this it is necessary to apply the same precautions to the fermentation in the rollers as in the fermenting room. It may be argued that the leaf cannot dry when it is rolled because it is enclosed in a box, but it must be remembered that the leaf is emptied out of the rollers every half-hour or so, and that this leaf has freshly expressed sap in its surface and is generally considerably warmer than the atmosphere. As soon as the leaf is emptied from the rollers the lumps are broken up and the whole put through the roll-breaker and sifter, which is designed to spread out the leaf in as thin a layer as possible while giving it a gentle upward throw. The fine leaf falls through the sieve and lies exposed to the atmosphere in a very thin layer, thus exposing the greatest surface possible to the air. At the same time if the rolling room windows are open, and this is very often the case, there is a circulation of air in the rolling room. This air movement may at times be quite appreciable, and during the hot, dry weather results in strong draughts of hot and dry air through the rolling room. The air conditions in the room are thus ideal for drying purposes, and, during the roll-breaking, the moist warm leaf is not only exposed to this dry air but everything possible is done to expose as much of the leaf surface as possible to it. It is impossible to avoid surface drying of the leaf under such conditions and damage is done to the leaf, especially to the fine dhools before they are removed to the humid atmosphere of the fermenting room.

It is thus necessary to maintain a high degree of humidity in the rolling room even if the leaf is not completely fermented in this room, but when that is done a high humidity is all the more necessary. Since the rolling room is a large room, efforts to maintain a high humidity by means of wet cloths and flowing water were even less successful than was the case with fermenting rooms so that humidifying plants must be used if a proper degree of humidity is to be maintained.

THE COOLING EFFECT OF HUMIDIFICATION.

When water changes its state from liquid to vapour it takes up heat. As a result of this phenomenon, the water in the muslin of a wet bulb thermometer requires heat when it evaporates in a dry atmosphere to water vapour. The heat necessary for this change is obtained

from the bulb of the thermometer and the air in the immediate vicinity of that bulb. This results in a loss of heat from the wet bulb thermometer and the cooling effect is shown by a drop in the temperature recorded by this thermometer. Evaporation of water into the air therefore requires heat, and when this heat is obtained from the atmosphere it results in a final cooling of the humidified air. Artificial humidification is generally obtained by forcing water under pressure through a narrow orifice in such a way as to obtain a fine spray of water. The water particles in this spray have to be very fine so as to expose as large a surface area as possible to the air if the water is to be vaporised quickly, and in a proper system this spray formation or atomisation is so well arranged that there is no visible mist a few feet from the jet owing to a complete vaporisation of the water. The heat required for the vaporisation of this water is obtained from the surrounding air, so that humidification results in cooling the air at the same time. The greater the amount of water which can be evaporated the greater will be the cooling effect produced, but the limit of cooling is controlled by the temperature of the wet bulb thermometer exposed to the unconditioned air, *i.e.*, the lowest temperature possible with humidification is that of the wet bulb thermometer. Thus, if the outside dry bulb thermometer reads 86°F. and the wet bulb thermometer reads 70°F., the readings inside the rolling and fermenting rooms can be reduced to 71°F. on the dry bulb thermometer, but the wet bulb thermometer should still read 70°F. when the air is completely humidified. This gives an atmosphere 15°F. cooler than would be the case without humidification, which allows the rolling to be carried out under conditions which prevent any unnecessarily high temperatures in the leaf mass during the process, provided all other precautions are taken. At the same time a cooler atmosphere is obtained for fermentation, which is of great benefit in a hot climate. On the other hand, humidification may result in too much cooling for a proper fermentation when fairly low temperatures exist along with comparative low humidities. In such instances the temperatures may be reduced below that necessary for fermentation, but it is advisable to avoid being dogmatic on this point until further investigation has clearly shown what is the proper temperature range for fermentation.

CONTROL OF AIR CIRCULATION.

Humidification is closely bound up with that of air control, and unless the air circulation in a room is under control it is almost impossible to effect successful humidification. It is of no use trying to maintain a high humidity in a room which is open to the outside air, but it is not unusual to see a few humidifying units in an open room. The effort is wasted, since it is just like trying to fill a bucket with a hole in it capable of passing through as much water as is poured into it. One of the benefits of humidification is that of cooling, but this

cannot be successfully obtained if the hot outside air is allowed free entry into the room. There need be no great movement of air outside for this to happen because the cooling effect produced in the locality of the humidifiers will set up air currents in the room, and heat will always travel towards the cooler regions. Very often elaborate precautions are taken to avoid the entry of any hot air from the drying room to the rolling room, although the tendency is for the air to be drawn from the rolling room to the firing room by the fans, while at the same time no attempt is made to keep out the outside hot air. The greatest cooling effect, and thus the most successful humidification, can only be obtained when the room is insulated in such a way as to prevent the entry of any external heat. It is impossible to prevent this altogether as it is absolutely necessary to introduce fresh air into the room, but the water sprayed into the air by the humidifiers must be sufficient to supply the water vapour required by this air so as to increase its humidity to 90 to 95 per cent saturation. Successful humidification can only be carried out therefore in a closed room possessing well-insulated walls and in which the air circulation is under control. The humidifiers themselves generally act as ventilators by drawing in a current of outside air and passing this through the zone of water spray; but if the humidifier is simply a device for producing a spray of water it is necessary to have a separate arrangement for the supply of fresh air and for the exit of the vitiated air. Fermenting tea requires a supply of oxygen and so do the operatives, but the amount of fresh air which must be supplied in order to keep the atmosphere sweet and fresh has never been determined. On the other hand a constant supply of fresh dry air is very essential to derive the benefits of the cooling effect of humidification. If the air circulation is slow it is quickly saturated, and the amount of water vapour which can be evaporated in a given time is also low, *i. e.*, the cooling effect will be little and the leakage of heat into the room will tend to raise the wet bulb temperature in the room. It is therefore necessary to have a good supply of fresh air in order to maintain the proper degree of cooling in the room, and also essential to check the wet bulb temperature in the rolling room against that of the outside wet bulb temperature. If the wet bulb reading inside is greater than that outside, there is stagnation of air in the room and the ventilation needs attention. The humidity and temperature of the rolling and fermenting rooms are thus bound up with ventilation, and it is necessary to control the supply of air as well as the supply of water to the jet of the humidifier. The humidifying installation must be capable of passing enough water in a fine spray in a certain time to supply all the water required for saturation of the volume of dry air admitted in the same period. Too much water must be carefully avoided, otherwise a

deposition will occur on the floor of the room and this is to be deprecated. This should not occur with a properly arranged system working at about 90 per cent saturation. The maintenance of such a high degree of humidity may tend to produce moulds and bacteria in the rooms unless precautions are taken to dry and aerate the room at the end of the day's work. This can be done by opening the windows and ventilators, turning off the water supply, and drawing a strong current of dry air through the room.

To sum up it can be definitely stated that fermentation should be carried out in a very humid atmosphere and that the benefits of humidification are:—

(a) It prevents surface blackening or drying of the fermenting leaf and thus gives a more even fermentation, resulting in more uniform infusions and brighter liquors.

(b) It produces cool conditions for fermentation and rolling, especially for rolling.

THE INFLUENCE OF ROLLING IN FERMENTATION.

There is no doubt that the manner of rolling is also of great importance in fermentation, but very little investigation appears to have been carried out in this direction. The method employed in applying pressure, the time taken for rolling and the speed at which the rollers rotate vary considerably among the various tea-producing countries.

Carpenter and Harrison (*Manufacture of Tea in North-East India*, 1927.) state that the speed of rolling has little or no effect on the tea produced, provided that the number of revolutions is the same in each case. This means that slower rolling involves a longer rolling period and therefore more rollers per factory. In one experiment, one roller revolved at 58, while the other revolved at 78 per minute for the same period. The fast roll gave 20% B.O.P. and 10% O.P., whereas the slower rolling gave 10% B.O.P. and 20% O.P. with very much more tip than the fast rolling. On the other hand the liquors from the fast rolled tea were better than the others. Their experiments have shown that hard rolling gives stronger teas but more stalk than light rolling. Finally, they recommend a roll of 55 r.p.m., carried on as long as possible with hard pressure, but draw attention to the importance of the humidity and temperature of the rolling when this is done.

Deuss (*Handleiding v.d. Thee Bereiding*, 1922.) draws attention to the need of great care in filling the rollers and warns his readers against filling the first roller too quickly, otherwise the leaf balls too much and flat leaf results. He recommends a slow, continuous supply of withered leaf into the rotating roller, and that the roller should thus be gradually filled.

The period advised in the case of the first roll is 15 minutes, as he claims that this will give very well twisted leaf. According to Deuss the first roll should not be faster than 50 r.p.m., and 45 r.p.m would be preferable; 50-55 r.p.m. for the second; and 55-60 r.p.m. for the third. Higher speeds than this are detrimental. He points out that the time for applying pressure depends on the time the leaf takes to acquire a twist, so that if pressure is applied before this has occurred too much broken leaf will be obtained and the tea will contain too many flaky particles. There is no doubt that all these questions are important in relation to the shearing effect of the rolling on the leaf and the way in which the various parts of the leaf are separated for fermentation, but the manner in which they affect the fermentation is not dealt with. The pressure applied affects the temperature of the leaf in the rollers, and with heavy pressure this temperature tends to run high so that it is necessary to lift the cover occasionally during the rolling to allow this heat to escape, while sifting should be very carefully carried out. Very little appears to be definitely known about the rolling process, so that it is very necessary to determine how various degrees of withering and different kinds of leaf affect the simple breaking up of the pluck in the rollers, and how these varying factors as well as the pressure applied and the speed of rolling affect the temperature of the leaf and therefore its fermentation.

(*To be continued.*)

SMALL SCALE EXPERIMENTAL MACHINERY FOR THE ST. COOMBS FACTORY.

ROLAND V. NORRIS.

An intimation has now been received from the Empire Marketing Board that a grant of £1,000 to the Tea Research Institute has been sanctioned for the purpose of installing small scale experimental machinery.

Such machinery is required in order that various modifications in manufacture may be tested out under definitely controlled conditions without the necessity for employing large quantities of leaf or interfering unduly with the commercial side of the factory. Such plant will also enable manufacture to be carried out with the small quantities of leaf available from the experimental plots and thus make it possible to investigate the effect of different cultural and manurial treatments, etc., etc.

Arrangements have now been completed for the installation of such machinery which, it is hoped, will be available before the end of the present year, and it may, therefore, be of interest to give a short description of the plant.

WITHERING TATS.

These will consist of small movable banks of tats 7 ft. 6 ins. high by 5 ft. wide, capable of taking about 42 lb. of leaf. Eight such banks will be constructed, these being accommodated in one of the factory lofts now vacant. Each bank, being on wheels and easily movable, can be placed in any position of the withering loft, while a reversible withering effect can be attained by simply reversing the tats themselves. Arrangements are also being made for suspending these banks, if required, with a balance attachment so that the loss of weight of the leaf during withering can be directly followed.

ROLLERS.

These have been specially designed by Messrs. Marshall Sons & Co., and are double action machines with a 16-in. box. Each roller will therefore be capable of dealing with about 30 lb. leaf. Even smaller quantities of leaf will have to be treated in the later rolls, and the machines will be adapted for this purpose by the use of a removable liner in the leaf box and an adjustment of the pressure cap. Four such rollers will eventually be in operation in order that four different samples of leaf may simultaneously be treated. At the moment, however, only two rollers have been ordered so that these may be experimentally tested before the remaining two are constructed.

ROLL BREAKER.

The frame of an ordinary roll-breaker (2 ft. × 7 ft.) will be utilised, this being fitted with four separate detachable sieves, each 20 ins. × 20 ins., so that four separate samples of leaf can be treated simultaneously under the same conditions. Each sieve will have its own separate catchment box.

DRYER.

In order to avoid the use of a separate heating stove, the experimental dryer will be connected up to one of the existing T.T. dryers in the factory. The complete dryer will consist of four separate cubicles each 18 in. wide and connected up to hot and cold air manifolds, the air supply from each manifold being provided with control valves. There will thus be suitable provision for temperature control and air supply while the direction of circulation of hot air is also capable of change.

The above plant will thus provide facilities for the simultaneous treatment of four samples of leaf and enable small scale manufacture to be carried out under widely varying but strictly controlled conditions. It is admitted that the results obtained cannot be entirely comparable with those obtained with full sized plant, but it should be possible to collect data in this way of the very highest value which will be checked later by full scale experiments.

SOME PROBLEMS RELATING TO TEA.*

ROLAND V. NORRIS.

In a few weeks' time the Tea Research Institute will be removed from the temporary quarters in Nuwara Eliya to its permanent home at St. Coombs, and considerably greater facilities will be available, both in the laboratory and in the field, for the work of the staff. The present, therefore, seems an opportune time to review briefly some of the more important problems demanding investigation, since it will now be possible to take these up in a more thorough and systematic manner.

Work on many of these problems is, of course, already in progress and data of importance have been collected. It is not however proposed in the present article to deal in any detail with the results already achieved, since these have been described in the Annual Reports and other reviews, but rather to describe the general lines of future work.

To begin with one is faced with our profound ignorance of the physiology of the tea bush. It is a striking fact that although in other crops, of which cotton may be cited as a conspicuous example, the trend of modern research has been directed towards a study of the living plant, this line of attack has been almost completely neglected on work on tea. It cannot be doubted, however, that such knowledge is absolutely fundamental. At the present time we have practically no reliable information at all regarding the plant itself and its response to different conditions of growth and treatment. As a result of this, our methods of cultivation, etc. are based on little real foundation and have been in large measure copied from the practices in vogue in other countries where conditions may be totally different. There cannot be any doubt whatever that as a result of such haphazard treatment large areas of tea are deteriorating and the situation is not one that can safely be allowed to continue. We must know something more of the life-history of the plant, of what is going on inside the plant, of the manner and rate at which it builds up its food reserves for example, the effect on the plant itself of different systems of pruning, cultivation, manuring, etc. A knowledge of such reactions would enable us to adapt our treatment of the bush to its special requirements at different stages of growth and under varying climatic and soil conditions. Let us consider the question of pruning. We prune because the bushes stop flushing and it is necessary to encourage the formation of new shoots. But why does the bush stop flushing ? That is a question which at present

* This article is based in part on a lecture delivered before the Dolosbage-Kotmale Planters' Association.

we cannot answer and which we are unlikely to be able to answer until we have much more information at our disposal regarding the processes of assimilation and transpiration. We must remember that the formation of starch, the chief food reserve of the plant, takes place in the leaves. Some of this food supply is at once utilised in growth and the formation of new shoots while the remainder is stored in the stem and roots. What is the balance between these two processes when a bush is in plucking ? This question is of course also connected with the uptake of other nutrients by the plant, a process which takes place through the root system and both are influenced by climatic conditions such as temperature, humidity, amount of sunshine, etc. The whole process of assimilation is a delicately balanced one and it is probable that it is through some gradual disturbance of this balance that the bush eventually stops flushing.

I have mentioned that the uptake of nitrogen and mineral nutrients takes place through the roots. What is the effect of pruning on the root system ? Opinion on this point seems divided though there is a fairly general idea that the roots die back after pruning. There seems to be little experimental evidence to support this and it is a point which ought to be cleared up. If such root die-back does take place, we require to know how far this is influenced by the severity of the pruning system, since this will react on the ability of the bush to recover after pruning. This ability to recover is, of course, one of the main problems of pruning and a rational system of pruning can only be based on a fuller knowledge of the physiology of the bush. When you remember that carbohydrate formation takes place only in the leaves, it will be obvious that after hard pruning, when the bush is left in a leafless condition, new growth can only take place through the utilisation of such reserve food materials as the bush has been able to accumulate before pruning. No application of manure at the time of pruning can increase this supply, as further quantities of starch cannot be produced until new leaves are formed. This does not suggest that a pruning mixture may not be beneficial when the food reserves are ample. In that case the manure may help the plant in its utilisation of the reserve starch and it will also come into play when leaf formation has begun so that quicker recovery may take place. But the important point is that when hard pruned, the bush cannot be expected to throw out new growth unless a food reserve is available. It is therefore clear that every effort should be made to treat the bush in such a way before pruning as to ensure the presence of adequate food reserves at the time of pruning. Whether this can best be done by resting the bush or by suitable manurial treatment *prior* to pruning are points which can only be decided by experimental investigation. Similarly, the

effects of different systems of pruning, "lung" pruning for example, and of pruning at different times of the year call for detailed examination in regard to their effect on the vitality of the bush itself.

A knowledge of the physiological requirements of the bush should also do much to improve manurial practice. At present, it is to be feared, manuring is largely a matter of routine and the programme is arranged chiefly to fit in with other work on the estate, regardless of the particular requirements of the bush at the time. Not only, is this true in regard to the time of application but also in regard to the make up of the mixture employed. The efficacy of manuring has very largely been judged by considerations of immediate yield only. A wider view should be taken and the effect of manures on the general vigour and life of the bush should also be studied. Were this done we might hear less of some of the diseases which are now prevalent and there would be less reason to anticipate a serious deterioration in our tea.

Considerations such as the above emphasise, therefore, the importance of carefully thought out manurial experiments and such experiments will form an important feature of the work at St. Coombs. It will be as well, however, to emphasise that work of this kind requires a considerable time before dependable results can be expected. The errors necessarily inherent in field experiments are not generally appreciated and considerable ingenuity is required, not only in reducing such errors to a minimum, but also in devising the experiment in such a way that the magnitude of the error can be determined and the value of the results accurately assessed. Lack of consideration of these factors in the past has vitiated the usefulness of much of the earlier manurial work on tea and led to much confusion owing to the contradictory results apparently obtained.

Any programme of manurial work must take into consideration such questions as the type of fertiliser most suitable to tea, the time and frequency of application and the amount of plant food to be supplied, while these factors have to be considered not only in relation to tea in plucking but also with regard to pruning mixtures. Moreover, the influence of soil and climatic conditions and of cultivation methods on the manurial requirements of the crop must also be examined.

It has already been suggested that manuring should not be considered only from the point of view of immediate yield. There can be little question that the policy of undue and continual forcing to obtain flush, which is sometimes adopted, is a risky one. In such cases, no effort is as a rule made to build up the permanent soil fertility, and in times of depression when a high manurial level can perhaps no longer be maintained, there is every likelihood of a severe

reaction and serious deterioration in the tea. It would appear preferable to ascertain what is a suitable economic limit for any particular estate, the manurial programme being so arranged as to maintain this level and at the same time increase the soil reserves. A reasonably high and gradually increasing *average* yield figure is much more likely to be obtained in this way, with less chances of any serious setback when unfavourable conditions occur.

The consideration of soil improvement leads to the question of cover crops and green manures. There is ample evidence that the intelligent use of such crops is one of the most rapid methods of improving the soil and building up its fertility. Moreover, their importance in limiting soil erosion is being increasingly recognised and has been frequently emphasised in these pages. The choice of a suitable variety often, however, presents difficulty, while the question of what constitutes proper management of such a crop is also a matter requiring investigation. It is evident, therefore, that field trials of a large number of such crops are desirable, in which the habits of growth, yields, response to cutting and cultivation and the general characteristics of the crop can be studied under comparable conditions. Arrangements are in hand for work of this kind at St. Coombs.

The value of such crops in relation to soil erosion will also be considered and this work will be supplemented by observations on the relative efficiency of the various systems of drainage now advocated. Bunded drains of the Felsinger type will first be studied and the influence of such a system on the run-off and percolation investigated. As such factors may be expected to affect the soil moisture balance, determinations of soil moisture and temperature will also be made. Later, as new clearings are made, alternative systems of drainage will be studied.

In dealing with the physiological study of the bush, reference was made to the necessity for an examination of those factors which influence the general vitality of the bush. Such a study would have a further implication in the light it should throw on the susceptibility of the bush to certain insect and fungus diseases. A weakly, run-out bush is obviously more likely to succumb from such causes and conversely a healthy bush will effect a quicker recovery. While it is not for a moment suggested that such diseases can be eliminated merely by improved manurial and cultural practices, it certainly seems desirable that in field experiments of any kind, the incidence of disease under the various treatments carried out should be studied.

But the chief defence against such diseases must lie in a study of the organism responsible, its method of propagation and spread and methods for its elimination or control. But in some diseases the determination of the actual causal factor is a most difficult thing

however. It has to be ascertained whether any particular fungus found associated with the diseased tissue is the primal cause of the trouble or a secondary factor only. If the disease can be communicated by inoculation experiments the problem is simplified, but a negative result is not necessarily conclusive, as it is frequently impossible to reproduce artificially the conditions under which the disease normally appears in the field. The elimination of the causal agent when found presents even greater difficulties. In root diseases particularly this is the case in view of the resisting power of the fungus spores which can persist for long periods in the soil even under unfavourable conditions. Destruction of the fungus in the soil with chemical disinfectants is therefore hardly likely to be a practical proposition, but the possibility exists that some form of biological control might be feasible though this line of attack has not yet received serious attention. At present, however, the chief safeguard against extensive damage lies in the early recognition of the disease, enabling steps to be taken for its control before it has become too widespread.

Insect attacks, on the other hand, while capable of causing severe losses offer greater possibility of control in that the causal agent is more readily recognised and more susceptible to preventive measures. In addition to artificial control by means of sprays and so forth, the potentialities of biological control have now been well established in many parts of the world. In Ceylon, such a method seems promising in regard to Tortrix and work on these lines is already being carried out. It is by no means unlikely that similar methods may also be feasible in the case of Nettle Grub. The possibilities of this line of attack against insect pests in general are, in fact, such that, if funds are forthcoming, it is hoped to make a general survey of the pests of tea and other crops in Ceylon and of the parasites which attack these.

The importance of the study of the living plant has been continually stressed in the present article and this applies with equal force when we come to consider the question of manufacture. Manufacture, as at present carried out, is admittedly an empirical process and based on no exact knowledge either of the material undergoing change, the nature of such changes, or of the agencies responsible for bringing these about. As a preliminary to a serious study of tea manufacture, further information must be obtained about our raw material, that is to say in regard to the composition of the fresh leaf and the variations in such composition which take place as a result of seasonal or other factors. Work already carried out has shown that such variations are considerable, both the "extract" and tannin contents of the leaf, for example, varying

inversely with the rainfall. Moreover, such variations persist in the made tea and affect quality. It is, therefore, obvious that there is no such thing as standard conditions of manufacture even in any one factory and the surprising thing is that the variation in quality of out-turn is not very much greater than is actually the case.

Most factories, I presume, claim to work to a definite percentage wither. It is doubtful whether such claims would stand close investigation but in any case there is no doubt that the actual moisture content of the leaf coming to the rollers varies between fairly wide limits, particularly of course in the wet season. But loss of moisture is not the only important consideration in withering. Evidence accumulates that definite changes take place within the leaf which are reflected in the amount of soluble material which can be leached out of the leaf after withering. A study of such changes and of the influence upon them of the withering conditions is therefore of urgent importance. Only in this way can we arrive at any knowledge of the material coming to the rollers and forming the raw material for fermentation.

A study of what takes place in the rollers is equally of importance, especially when it is remembered that fermentation begins as soon as the leaf is crushed. The conditions of rolling must therefore have a profound influence on the quality of the product, and it is obviously desirable that the material treated should be as uniform as possible. Otherwise, there will be marked difference in the way in which the pluck breaks up and in the various fractions obtained in the different dhools. In other words, the conditions of fermentation from day to day will vary within fairly wide limits and uniform products can hardly be expected.

The earlier stages of fermentation, in the rollers, are of special importance in view of the fact of the production of the essential oils, to which the flavour of tea is very generally ascribed, takes place chiefly at this period. As fermentation proceeds, the rate at which the essential oil is produced falls off and the time of maximum formation does not necessarily coincide with the time required for the production of good liquors. In this connection temperature has to be considered. It is, of course, a matter of general observation that considerable heat is produced during rolling. This is only in part due to the friction involved, much of the heat being due to the chemical changes taking place. When the leaf is spread out for fermentation the production of heat still continues, though, under the conditions in which this is usually done in Ceylon, the rise in temperature may not be very noticeable, the heat being rapidly dissipated.

A considerable amount of work has already been carried out on the influence of such temperature changes, but the question as to what is the optimum temperature cannot yet be considered as settled. It is possible that there is a fairly wide working range but there is no doubt that the temperature developed in the rollers, particularly when heavy pressure is employed, may be considerably higher than is desirable and lead to a serious loss in quality.

The whole question of temperature control with its associated problems of humidification and ventilation, is therefore a complicated one and it cannot be claimed that the subject has yet received adequate attention, particularly in regard to the conditions obtaining in low-country factories.

It is hoped that the facilities available at St. Coombs may enable an intensive study to be made of the problems briefly outlined above. The installation of the small scale machinery described elsewhere in this issue will enable each process of manufacture to be carried out under controlled and widely varying conditions. At the same time the nature of the chemical changes taking place during manufacture will be followed in the laboratory when it is hoped data may be accumulated, enabling some conclusions to be drawn as to the factors constituting quality and the conditions governing its production.

QUARTERLY REPORT ON THE WORK OF THE SCIENTIFIC STAFF OF THE TEA RESEARCH INSTITUTE.

Forty-eight consignments of diseased plants have been received for examination by the Mycologist during the quarter under review. Root diseases were the most common, accounting for twenty of these specimens. An unusually large number of diseased seedlings have, however, been submitted, but in no case could the cause be ascribed definitely to a mycological origin. In the past, it has been usual to group the non-mycological diseases under the heading of 'Bitten-off' and 'Collar Rot.' The symptoms of the latter group are distinct and the cause has been attributed to sun injury, though there is no experimental evidence on tea to verify that assumption, though by analogy with other work the assumption is sound. 'Bitten-off' is sometimes caused by excessive soil moisture and more frequently by unsuitable soil reaction. Other physiological causes may lead to the same symptoms. A third type of disease has been prominent recently which is characterised by a dwarfing of the leaves and a shortening of the internodes. There is no symptom of 'Bitten-off' and the disease usually shows up as soon as the food reserves of the seed are exhausted. There is no evidence to indicate that this disease is the result of attack by parasitic fungi.

Two new types of branch canker have been observed during the quarter. One occurred on young seed bearers and is of a similar type to that found on tea in bearing. The common form found in the low-country is caused by *Macrophoma theicola*. This fungus was not found on the specimens from seed bearers; instead a species of Physalospora was present. Unfortunately it was not mature and could not be completely identified. It does not appear to be identical with *Desmotascus neglectus* (*Physalospora neglecta*) which is regarded as the perfect stage of *Macrophoma theicola*. It is believed that the fungus in question has been obtained in pure culture (though as yet it has not fructified) and it has been used for inoculation experiments.

The other type of branch canker was received from South India where it is considered to be a serious disease. So far it has not been reported in Ceylon. The cause is possibly of mycological origin, but attempts to isolate a causative organism have not proved successful.

A further case of *Armillaria fuscipes* causing a root disease of tea was found in the Nuwara Eliya district.

The Witch's Broom disease of tea is probably more widespread than is generally recognised. Recent observations indicate that some forms of the disease spread slowly and a possible agent of dissemination is the pruning knife. This again brings to the front the possibility that the disease is a form of virus. Previous experiments in this

direction were unsuccessful and inconclusive. Further experiments on budding and grafting have to be devised and it appears probable that stumps in pots will form a better medium for experiment than plants in the field such as were used previously.

A few seeds have been collected by the Mycologist from Witch's Broom affected bushes and germinated. The resulting plants are being raised in pots, and it is hoped by this means to determine whether the virus (if any) may be carried in seed. Seeds collected from healthy bushes are being grown for comparison.

The Entomologist has continued his work on the breeding of Trichogramma. In the last quarterly report reference was made to the difficulty hitherto experienced in obtaining a large and regular supply of moth eggs for parasitisation. It is believed that this difficulty has now largely been solved, and whereas up to the middle of June the daily supply of eggs was only about 4,000, the number had been increased to a daily figure of 20,000 by the end of the month, and the Entomologist anticipates that the number will read six figures before very long. The rate of increase of the parasite, however, is still unsatisfactory. As already pointed out, it seems likely that the reason for this may lie in the relative sizes of the grain moth egg and the parasite, the latter measuring 1 mm. in body length when derived from a tortrix egg and only 0·67 mm. when derived from the grain moth egg.

Trichogramma erosicornis, the species indigenous to Ceylon, is somewhat larger than the species which have been successfully propagated on the large scale elsewhere. Steps have therefore been taken to obtain specimens of a smaller species. This should be available very shortly when it is hoped the difficulties hitherto experienced may very largely disappear.

Attempts have also been made to find a strain of Trichogramma which would parasitise the eggs of Nettle Grubs. Though frequent attempts were made by the parasite to oviposit on such eggs, no development occurred. Such eggs, however, failed to give rise to a caterpillar.

Systematic work on Nettle Grub has, however, now been taken up by Mr. Austin under the direction of the Entomologist. This work falls under three heads:—(1) Study of the life history of different species of Nettle Grub, (2) Methods of biological control, and (3) Methods of artificial control.

Under heading (1) a study of the life history of *Natada nararia* was started in April and valuable data were collected regarding oviposition, longevity of the moths, etc. In May further experiments were started with 12 broods of Natada larvae. Unfortunately, the work has been seriously impeded by the outbreak of wilt disease which

has caused a heavy mortality among the laboratory material. It would appear, however, that the Natada moths live up to a maximum of 11 days in captivity. Oviposition takes place after dusk within 24 hours of emergence. In the field the eggs are deposited singly and mostly on the upper surface of the leaves. The maximum number of eggs deposited in the laboratory by a single female was 428. These hatch within 6-8 days. Larval periods ranged from a minimum of 29 days to a maximum of 42 days, and pupal periods from 18-21 days.

A few studies have also been made of *Thosea cervina* and *T. recta* but these were interrupted by the outbreak of wilt. A temporary insectary has now been erected in the bungalow compound and a fresh series of experiments started.

In regard to the biological control of Nettle Grub, Mr. Austin has begun a systematic search for Nettle Grub parasites. The breeding of any parasites so found is not an easy matter, but a certain measure of success has already been attained. Among parasites so far examined, two, a species of Rhogas and a species of Apanteles, both seem of promise. *Rhogas sp.* has been found to parasitise at least four species of Nettle Grub and, as its life cycle occupies only a fortnight, it passes through two generations during the larval period of its host. It may therefore be of economic importance. *Apanteles sp.* is a gregarious parasite of both *Thosea cervina* and *T. recta*. Over a hundred parasites can be obtained from each parasitised grub. No egg parasites have so far been recorded.

In regard to artificial control, Mr. Austin has carried out a number of tests with various insecticides, both in the laboratory and in the field. Encouraging results have been obtained with two pyrethrum preparations "Uno" and "Pysect," with "Clensel" and also with soaps. "Salbar," a lime-sulphur preparation, and "Necrosene," another patent insecticide, however, gave no useful results.

The general observations made by Mr. Austin confirm those made last year that *Natada nararia* is the predominating species at the Badulla end of the Passara area, while *Thosea cervina* predominates at the Lunugala end of the district.

It is of importance to note Nettle Grub has now been reported from the Pussellawa district.

The Agricultural Chemist has been engaged in the analysis of the leaf obtained from the Scrubs Uniformity Trial. The ash, potash and phosphate figures are now complete and ready for consideration. Much time has also been spent in field work in preparation for the manurial experiments to be laid down at St. Coombs. The plots have now been demarcated and preliminary pluckings (prior to pruning) will commence in the near future.

Attention has also been given to the soil conditions attending the obscure affection of nursery seedlings at St. Coombs referred to earlier in the present number (p. 71).

The Biochemist has continued the investigations outlined in the last report. In addition, observations have been made from time to time of the changes occurring in withering leaf. These experiments support the contention that withering is accompanied by quite well defined changes other than loss of moisture. In regard to moisture losses, moreover, there is evidence that the speed at which this occurs is to some extent controlled by the leaf itself, a fact which becomes of importance when considering the application of artificial conditions for withering. As the wither proceeds and the sap concentration is increased, there is a greater resistance to the loss of moisture. If vigorous drying conditions are employed in the later stages of withering, there is, therefore, a greater risk of surface drying. These considerations suggest an interesting line of investigation.

When fresh leaf is allowed to stand in water some of the leaf material is leached out. This amount is, however, considerably increased when the leaf has been withered and there is in fact a progressive increase in the percentage of leachable material as withering proceeds. Leaf which has been kept for similar periods but prevented from withering does not exhibit this change. These results show clearly that withering is accompanied by definite changes other than the loss of moisture. It will obviously be of the highest importance to elucidate the nature of these changes, and the whole phenomenon is being closely studied by Dr. Evans.

The Plant Physiologist has now commenced the study of the effect of pruning and plucking on the growth and food reserves of the bush. Work has, however, been somewhat impeded by the abnormally dry weather recently experienced. An experiment dealing with the influence of seed size and of shell removal upon the growth of tea seedlings is also in progress.

Preliminary experiments on the vegetative propagation of tea indicate that under climatic conditions such as were experienced at St. Coombs in May-June, a strike of about 40 per cent. can be expected from tea cuttings. This percentage is likely to be increased when more material is available, enabling a better selection to be made in the stems used for cuttings. While it would be premature to draw any definite conclusion at such an early stage of the work, it seems likely that the establishment of substantial clone stocks for experimental purposes will be possible.

ROLAND V. NORRIS.
Director.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE, CEYLON.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held in the Victoria Commemoration Buildings, Kandy, on Wednesday, the 9th July, 1930, at 2-15 p.m.

Present.—Mr. R. G. Coombe (Chairman), the Hon'ble Mr. W. Youngman (Director of Agriculture), the Hon'ble Mr. D. S. Senanayeke, Major H. Scoble Nicholson, Messrs. A. G. Baynham, F. F. Roe, John Horsfall, Jas. Forbes (Jnr.), T. B. Panabokke, Mr. F. C. Macdonald (Actg. Secretary), R. R. Muras (Actg. Asst. Secretary), and by invitation Dr. R. V. Norris (Director, Tea Research Institute) and F. J. Whitehead (Consulting Engineer).

Absent:—The Hon'ble the Colonial Treasurer, Messrs. J. D. Finch Noyes and G. R. Whitby.

1. Notice calling the Meeting was read.

2. Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held on the 1st April 1930, were taken as read and confirmed.

3. Letters regretting inability to be present at the Meeting were received from the Hon'ble the Colonial Treasurer, Messrs. J. D. Finch Noyes and G. R. Whitby.

4.—FINANCE.

(a) *Statement of Accounts as at 31st May 1930.*—The Chairman referring to these said that since the last Meeting the figures in the Capital Expenditure which were misleading had been adjusted, making the accounts, he felt, now quite clear. The accounts were passed without further comment.

(b) *Financial Statement to end June 1930.*—The Chairman said that there was approximately Rs. 150,000/- on current account, and a like amount on fixed deposit. The fixed deposit was due for payment on 4th August.

He anticipated that during the next three months a sum of from Rs. 180,000/- to Rs. 190,000/- would be required for buildings. which should be nearing completion in that time. He suggested that the question of whether it would be possible to place anything further on fixed deposit for a short period should be left in his hands. This was agreed to.

(c) *Increase of Cess.*—The Chairman announced that he was glad to be able to report that the Ceylon Association in London, the Ceylon Estates Proprietary Association, the Low-Countary Products Association and the Planters' Association of Ceylon, had all unanimously agreed to the increase of the Cess from -/10 cents per 100 lb.

to -/14 cents per 100 lb. for the next three years. A copy of the draft letter to Government in this connexion was sent to each Member of the Board under cover of Circular No. A. 15/30, dated the 5th June 1930.

The Acting Colonial Treasurer considered, however, that this letter was not full enough and was lacking in the several essential details which Government would require, especially when the matter came before the Executive Council. Another letter giving the information required had been drafted and forwarded to Government. A copy of this letter was sent to each Member of the Board under cover of Circular No. A. 18/30, dated the 4th July 1930.

The letter was confirmed without comment.

5.—MEMBERS OF THE BOARD, T. R. I.

The Chairman welcomed Mr. F. F. Roe, the new Chairman of the Ceylon Estates Proprietary Association, and Mr. Jas. Forbes (Jnr), Representative of the Planters' Association of Ceylon, *vice* Mr. D. S. Cameron. He also reported that Major H. Scoble Nicholson had been nominated to fill the vacancy caused by the resignation of Mr. P. A. Keiller, and that Mr. G. R. Whitby had been nominated to act for Major J. W. Oldfield.

A vote of thanks was recorded to Mr. Keiller for his services.

6.—ST. COOMBS ESTATE.

(a) *Laboratories.*—The Director reported that the Laboratory Buildings had made very good progress, since the last Meeting. The main structure was now complete. No trouble was anticipated in completing the building within contract time.

(b) *Water Supply.*—The Director said that Mr. Dyer, the Government Sanitary Engineer, had put forward a complete scheme for the water supply at St. Coombs, the estimated cost of which amounted to approximately Rs. 32,000/- exclusive of the Chlorometer plant required for the purification of the supply which would cost another Rs. 2,000/-. Gaugings had been taken by Mr. Dyer of the various supplies and spring D had been found to yield from a maximum of 118,000 gallons to a minimum of 21,000 gallons per day. The latter was the hot weather figure and was sufficient to cover the demand. The main item in Mr. Dyer's estimate was the 4 in. cast-iron main which alone absorbed Rs. 28,000/-. A modification of the above scheme had been proposed by Mr. Whitehead who had found that 4 in. galvanised piping could be obtained at a rate of about Re. 1-95 per foot and he suggested that this should be used instead of the cast-iron pipe costing about Rs. 6/- per foot. Other changes in the scheme were also proposed by Mr. Whitehead who then gave

details of his ideas. The 4 in. main would be brought to the laboratory site to a tank in the ground of 7,000 gallons capacity which would supply most of the quarters by gravity. For the laboratory and senior staff bungalows a 30 ft. tower would be constructed in the laboratory quadrangle. In view of some uncertainty as to whether the head was sufficient to carry enough water to the tower without pumping, Mr. Whitehead suggested the 4 in. main should be first laid and the head experimentally tested. As an alternative to pumping, it might be possible to obtain a greater head by tapping the source at a higher level. The estimated cost of his scheme amounted to Rs. 20,550/- made up as follows:—

Main line piping	...	...	...	Rs.	10,400 00
Chlorometer & Fittings	...	...	...	,,	2,150 00
Distribution piping and fittings		...	...	,,	6,500 00
Laboratory tank	...	...	...	,,	1,500 00
				Rs....	20,550 00

The supply for the factory, Superintendent's bungalow and estate lines would continue to be taken, as far as possible, from spring B near the factory. The Estate Sub-Committee which had considered both schemes in detail recommended that Mr. Whitehead's proposals should be adopted, the work being carried out in the two stages suggested. The Chairman proposed that the Board should approve this recommendation and this was carried unanimously.

(c) *Appointment of Temporary Visiting Agent.*—The Chairman announced that Mr. J. E. B. Baillie-Hamilton had agreed to visit and report upon St. Coombs in September next.

(d) *Roads.*—The Secretary read a letter from the Superintendent asking for an increase in the estimate for roads.

The Chairman asked the Board to sanction the expenditure recommended by the Estate Sub-Committee.

This was agreed to.

7.—BUNGALOWS—ARCHITECT'S REPORTS.

The Chairman said that copies of the Architect's Reports Nos. 12-14 had been sent to each Member of the Board.

Reporting progress made since the last Meeting the Director stated that the roof to No. 1 Bungalow was practically completed; and the roof trusses were on to No. 2 Bungalow. He anticipated that both Dr. Gadd's and his Bungalow (Nos. 5 and 6) would also shortly be ready for the ironwork of the roof.

Three of the Junior Staff Bungalows were being occupied, the 4th should be completed in about a month's time.

The quarters for the Subordinate Staff were also completed and ready for occupation, the two clerks' quarters were well advanced and should be ready when required.

8.—FACTORY EXPERIMENTAL MACHINERY.

Rollers.—Mr. Whitehead said he had been in consultation with Dr. Evans and the Director regarding the small scale experimental machinery. The Director had received a quotation from Messrs. Marshall, Sons & Company for a small 16 in. roller specially designed by them. This would take about 30 lb. withered leaf and could be adapted locally to deal with smaller quantites by fitting a liner and adjusting the pressure cap. The quotation for each roller was £106 *c.i.f.*, Colombo, so that the cost at the facory would be about Rs. 1,500. He considered this a very favourable figure and suggested that two rollers should be first ordered, the other two being obtained after tests had been carried out on these.

Withering Tats.—Mr. Whitehead submitted a design for a movable bank of tats capable of taking about 42 lb. leaf and costing about Rs. 200/-. The matter had been discussed with Dr. Evans, and it was considered that eight such tats would be necessary.

Driers.—To avoid the use of separate heating stoves, Mr. Whitehead suggested that the experimental small scale drier should be connected up by a manifold to one of the existing T.T. Driers. A design of the proposed arrangement was shewn. Both hot and cold air manifolds would be provided with valves permitting of temperature adjustments and the direction of circulation of the hot air could also be controlled. It was estimated that a drier of four units on these principles could be constructed for about Rs. 2,000/-.

Roll-Breaker.—Mr. Whitehead's design allowed for the use of the framework of an ordinary roll-breaker, provision being made for the insertion in this of four separate and movable sieves, each with its own catchment box. In this way four different samples could be dealt with simultaneously. The cost was estimated at Rs. 1,500/-.

The Chairman explained that on the basis of the above proposals which had been approved by the Estate Sub-Committee, the total cost of the experimental machinery, exclusive of erection, would be about Rs. 11,500/- viz:

4	16-in Rollers	Rs.	6,000	00
8	Movable Banks of Tats	,,	2,000	00
1	4-Unit Drier	,,	2,000	00
1	Roll-Breaker	,,	1,500	00
			11,500	00

This estimate was necessarily an approximate one, but there was every reason to believe it would not be exceeded. The cost would be covered by the grant of £1,000 made by the Empire Marketing Board for experimental machinery. He proposed the following resolutions:—

(a) That two experimental rollers be now ordered, purchase of the other two being deferred until tests have been carried out.

(b) That one withering tat be first constructed by Mr. Whitehead in consultation with Dr. Evans, construction of the remaining seven being put in hand if these be found satisfactory.

(c) That a four-unit drier be constructed on the lines suggested, one unit, however, being first made for experimental test.

(d) That one roll-breaker, as described, be constructed.

These resolutions were agreed to by the Board.

Mr. Horsfall proposed that the Director of Agiculture be asked to take the necessary steps to obtain exemption from import duty for the experimental machinery intended solely for tea research work.

9.—STAFF.

The Chairman announced that the Plant Physiologist had now taken up his residence in one of the Junior Scientific Staff Bungalows at St. Coombs, and that the Biochemical Research Assistant had also taken up his duties at St. Coombs as from 1st July.

10.—CEYLON NURSING ASSOCIATION.

The Chairman reported that the Senior Scientific Staff Officers had agreed to the terms of contribution to the Ceylon Nursing Association.

The Chairman asked confirmation that the Board would contribute a like amount.

This was agreed to.

11.—EMPIRE MARKETING BOARD.

The Chairman announced that a letter had recently been received from the Empire Marketing Board, sanctioning a capital grant of £1,000/- for the purpose of experimental machinery.

A cordial vote of appreciation was recorded to the Empire Marketing Board for this grant.

12.—PROVIDENT FUND FOR THE JUNIOR SCIENTIFIC STAFF.

The Chairman regretted that the Sub-Committee appointed to go into this matter had been unable to do so, a meeting was being held after the Board Meeting that day. The recommendations of this Committee would be circularised in due course.

13.—T. R. I. CONFERENCE, 1931.

The Chairman explained that the policy adopted by the Board was to hold a Conference biannually, alternately with the Conferences held by the Department of Agriculture. On this basis the next Conference should be held in 1931 and after consultation with the Director, the 26th and 27th February were suggested as suitable days. The

Institute Staff was strongly of opinion the Conference should be held at St. Coombs. He held the same view and thought the Board would be in agreement with this. The Institute would then be in its new home and the new laboratories in working order, while the experimental machinery would also be operating. There would, therefore, be much of interest to see at St. Coombs, and the Conference, if held there, would also provide excellent opportunities for valuable informal discussion between visitors and the Staff. Some District Planters' Associations had suggested that the Conference should be held at Kandy, but he was able to say that at the General Committee Meeting of the Planters' Association of Ceylon held that morning the suggestion had been withdrawn. Although sleeping accommodation could not be provided at St. Coombs, such accommodation would be available at Nuwara Eliya and Hatton, both within easy reach. Adequate arrangements could be made to supply lunch and tea, and he was confident that everything would be done to provide for the comfort of visitors. He therefore formally moved that the Conference be held at St. Coombs on 26th and 27th February, 1931. This was carried unanimously.

The Hon'ble Dr. Youngman mentioned that the Agricultural Department Conference would be held in September or October this year, but this would not in any way clash with the Institute's meeting.

14.—LETTER FROM DIRECTOR, TEA INSTITUTE OF PERSIA.

The Chairman referring to the letter received from the Director of the Tea Institute of Persia, which had been sent to each Member of the Board under cover of Circular No. A. 17/30, dated the 23rd June 1930, asked the Director to give his views on the matter.

Dr. Norris said that when the Director of the Tea Institute of Persia visited Ceylon last year he promised to give him certain assistance in the way of obtaining tea seed in Ceylon.

He had now written and asked if the Institute could arrange for a further supply of 50 maunds of seed, as well as to get him four specialised tea labourers (natives of Ceylon) to go over to Persia, three men for tea cultivation and one for tea manufacture (as chief of a factory). It was necessary that all four men should know a little English.

It was decided that the Director of the Persian Tea Institute should be referred to regular suppliers of tea seed. Further that these suppliers might be able to assist the Tea Institute with regard to engaging the Staff for Persia.

15.—ESTATE SUB-COMMITTEE.

On the Chairman's recommendation the appointments of Mr. Jas. Forbes (Jnr.), (*vice* Mr. D. S. Cameron) and Dr. R. V. Norris on the above Committee, were confirmed.

Referring to the Report of the Estate Sub-Committee held on the 4th July, the Chairman moved, and it was unanimously agreed, that the various recommendations embodied in the Report other than those already dealt with at this meeting be approved.

16.—PUBLICATIONS.

The Chairman said that a proprietary planter had made application for free issues of the Institute's publications, his estate still not being in bearing. He asked the Board to allow this application, which was agreed to.

The Meeting terminated with a vote of thanks to the Chair.

R. R. MURAS,
Actg. Asst. Secretary.

NOTICES.

Advisory Work.—Entomological enquiries should be addressed to Mr. C. B. Redman King at Mahagalla Bungalow, Norwood. Specimens sent by train should be consigned to Hatton Station c/o. Hatton Bank & Agency.

All other enquiries should be addressed to the Director, Tea Research Institute, Nuwara Eliya.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Superintendent may not be free to show them round. Such visitors on arrival at the Factory are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the Mattakelle turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's publications should be directed to the *Secretary at Victoria Commemoration Buildings, Kandy*, and *not* to the Director's office.

Tea Seed.—Enquiries are not infrequently received by the Institute as to the sources from which seed of various types can be obtained. If estates supplying seed care to send particulars to the Director, the latter will be in a position to put enquirers in touch with suppliers. Full details as to type of seed, elevation and rainfall of estate, etc., should be given.

Meantime an enquiry for China hybrid seed has been received, and the Director will be glad to hear of any estate able to supply.

ROLAND V. NORRIS.
Director.

EDITORIAL.

It is regretted that the present number is late in appearing but publication has been delayed as a result of the temporary disorganisation following on the transfer of the laboratory and offices of the Institute from Nuwara Eliya to St. Coombs.

The Nuwara Eliya laboratory and the branch entomological laboratory at Mahagalla have now been closed down and in future the work of all departments will be concentrated at St. Coombs. All communications for the Institute should, therefore, be addressed in future to The Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Specimens or other material sent by train should be consigned to Talawakelle, c/o Messrs. Hemachandra & Co., Forwarding Agents.

T. R. I. CONFERENCE.

The attention of readers is particularly directed to the notice enclosed in this number regarding the Second Conference of the Tea Research Institute. As already announced this will be held at St. Coombs on February 26th and 27th, 1931, when it is hoped a large number of visitors will avail themselves of the opportunity provided to inspect the new buildings. The subjects on which papers will be given at the Conference have been carefully chosen to afford scope for a discussion of the widest possible character, and it is hoped that the views of different schools of thought on the various problems raised will receive adequate representation.

The Conference will also be made the occasion for the official opening of the new laboratories and a further announcement on this subject will be made in due course.

It will greatly facilitate the arrangements for the Conference if those intending to be present will fill up the form attached to the notice and return this as soon as possible.

UNHEALTHY SEEDLINGS.

With reference to the notes which appeared in the last number of *The Tea Quarterly* on this subject and on a tea disease reported from Nyasaland, some interesting comments have been received from Mr. P. W. Davis of Olavakkot, S. India, from which the following extracts are taken:—

"A state similar to that attributed to disease in Nyasaland has in a number of cases been found in youngish clearings (under 6 years old) in South India and more particularly where shade trees have not been established and when there was a bad drought. In the case of old tea, presumably because it shades its own soil and has a larger

root, these symptoms have never been noticed by me. Cure in these cases is practically impossible so far as I know. Prevention is however easy. The remedies are two and should be used in conjunction one with the other.

1. Establishment of shade—a slow process.
2. A light fork of say 4 in. depth immediately after the last rains.

"This with a view to breaking up the capillary tubes of the top soil through which the moisture content of the soil is lost owing to the action of the sun's rays. This forking will definitely prevent the 'disease' from occurring in the subsequent dry weather, just prior to which the work must be done.

" 3. In nurseries the remedies are the same but in this case it is possible to cure the plants, as removal of the sun's rays is an easy matter by doubling the nursery thatch, while in an open clearing establishment of shade trees in a sufficiently short period is an impossibility. Provided extra thatch is put on pandals immediately 'yellowing' is noticed, the check plants have received will be overcome within a month. The usual glossy sheen will be restored to the old leaves and new shoots will appear, while the final result is that no difference will be noticed between affected and unaffected plants beyond the loss of growth due to the check.

"Simultaneously with the thatching the nursery must be dibbled to a depth of 1 in. to $1\frac{1}{2}$ in.

Finally, the cause of the formation of the hard cake and its capillary tubes is water and its action. Water must be applied in such a way as to minimise the crust-forming action. I am unable to give the reason but it is a practical fact that light watering in sunny weather forms the dangerous crust, a heavy sousing does not. Even if the number of applications of water is reduced, therefore, it is essential to see that it is a good watering and not a sprinkle."

THE ARMILLARIA ROOT DISEASE OF TEA.

C. H. GADD.

In 1910, Petch[6] described a root disease of *Acacia decurrens* in Ceylon caused by a species of Armillaria, which he had named *A. fuscipes* [5]. At that time the disease had not been recorded on tea. In 1918, Palm [4] published an account of a tea root disease from Java, caused by a similar fungus which, following Rant [8], he ascribed to *Armillaria mellea* (Vahl.) Fr. Armillaria root diseases of tea have since been reported from Uganda [10], Nyasaland [1] and Ceylon [3], but so far there appears to be no record of the disease occurring on tea in India, though the fungus is known to exist in the Himalayan pine forests [1].

There can be little doubt that the Armillaria root diseases of Ceylon, Java and West Africa are the same, and that the fungus which causes them is closely allied to *Armillaria mellea*, a well-known saprophyte and parasite of forest and orchard trees in temperate zones. A number of diverse forms of *A. mellea* are known, and Rea [9] lists ten varieties for Great Britain alone. Whether the tropical form should be regarded as a further variety of *A. mellea* or should be given specific rank under the name *A. fuscipes*, as Petch [7] maintains, is a matter for systematists to decide. At present, the name *A. mellea* is in common usage for the tropical fungus.

A peculiar feature of Armillaria root diseases in the tropics is that the tap root and lower part of the stem frequently split longitudinally. For this reason this tea disease in Java is known as "Splitkanker" [4], and the cacao disease of the Gold Coast as "Collar Crack" [2]. The fissures are usually coated with sheets of somewhat leathery, cream-coloured mycelium, termed xylostroma. This mycelium often extrudes from the split cortex as a narrow, raised ridge running vertically down the root; the ridge is often slightly frilled, and is usually dark brown or black owing to the change in colour of the external layers of the xylostroma. (Plate I, fig. 1.).

The radial fissures result from the formation of mycelial sheets in the medullary rays of the affected parts. It is doubtful, however, whether the pressure exerted by the mycelial sheets alone is sufficient to split the wood in the manner observed. Cases of this disease on old tea in Ceylon rarely exhibit the characteristic fissures at the time the disease is first observed in the field, *i.e.*, at the time the bush dies, but they usually develop as the bush dries out in the laboratory. The fissures so developed are not as a rule coated by definite mycelial sheets, but it is believed that in the field, such cracks would become filled with xylostroma as the fissures slowly form. It seems probable

that the unequal drying out of the variously affected wood, resulting from the interruption of the water current consequent to the death of the roots, sets up strains responsible for the formation of fissures at places prepared by the fungus.

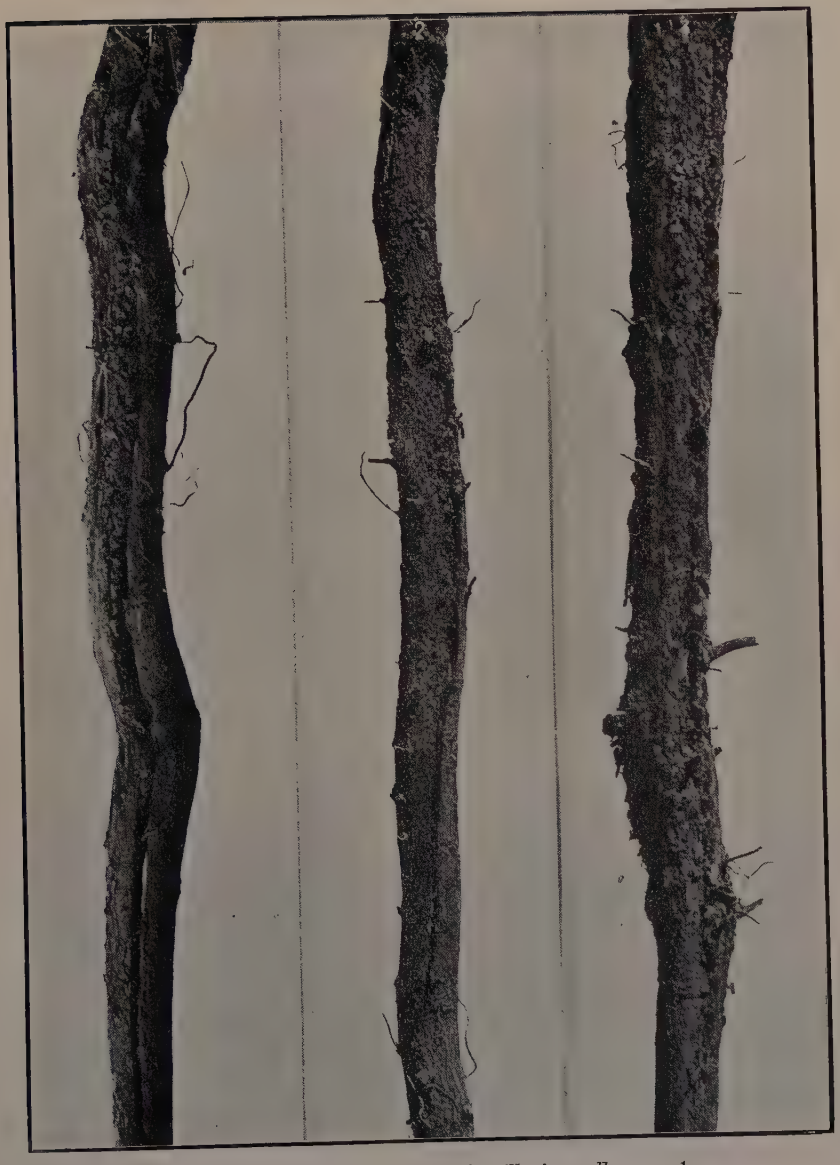
Though the peculiar fissures have not been observed in attacked mature bushes in Ceylon, they have been observed in *Albizzia lopantha* and in young tea plants about half-an-inch in diameter about to be transplanted. In some instances, the tap roots of the latter were split from the tip to the collar as though with a knife. Occasionally the roots were split along more than one plane so that the remains of the tap root had the appearance of having been trimmed to a point. Photographs of such roots were published elsewhere (3). In others, narrow fissures occurred in the cortex, from which exuded frills of xylostroma forming vertical, raised bands down the root. Fissures and frills of xylostroma are shown in Plate I.

Another feature by which this disease can be identified is by the presence of black, somewhat flattened, rhizomorphic strands which resemble black roots about one sixteenth of an inch in diameter (Plate II Figs. 2 and 3). These black cords or rhizomorphs are rather brittle, and are usually broken during uprooting operations. Fragments, however, may usually be found attached to the cortex. The rhizomorphs are not confined to the surface of the bark but run freely for long distances through the soil. Under African conditions, as in Nyasaland on tea and in the Gold Coast on cacao, the formation of definite rhizomorphs appears to be rare in nature though they are readily produced in artificial culture.

In the absence of rhizomorphic strands or extrusions of xylostroma, there is no visible fungus on the exterior of the roots. The bark is much roughened and when shaved away tangentially, sheets and strands of white mycelium running parallel to the surface of the bark may be observed (Plate II. Fig. 5). Frequently, thin but compact fans of mycelium occur between the wood and the bark in the place of the cambium. In this respect the disease resembles that caused by *Ustulina zonata*. In the latter disease, the mycelial fans are larger and are usually confined to the cambial layer. The mycelial fans of Armillaria are thicker, with a reddish brown outer covering, and are also to be found within the cortex. The Ustulina fans are best seen by lifting an area of cortex away from the wood, whereas the Armillaria strands and sheets are most easily found by shaving the cortex, which then has a mottled appearance due to the alternating areas of white mycelium and brown bark.

The wood of Armillaria infested tea roots in Ceylon is typically hard and dry, and is divided into definite areas that differ in appearance and stage of decay (Plate II Fig. 4). These areas are frequently

PLATE I.



Young tea plants attacked by *Armillaria mellea*. x1.

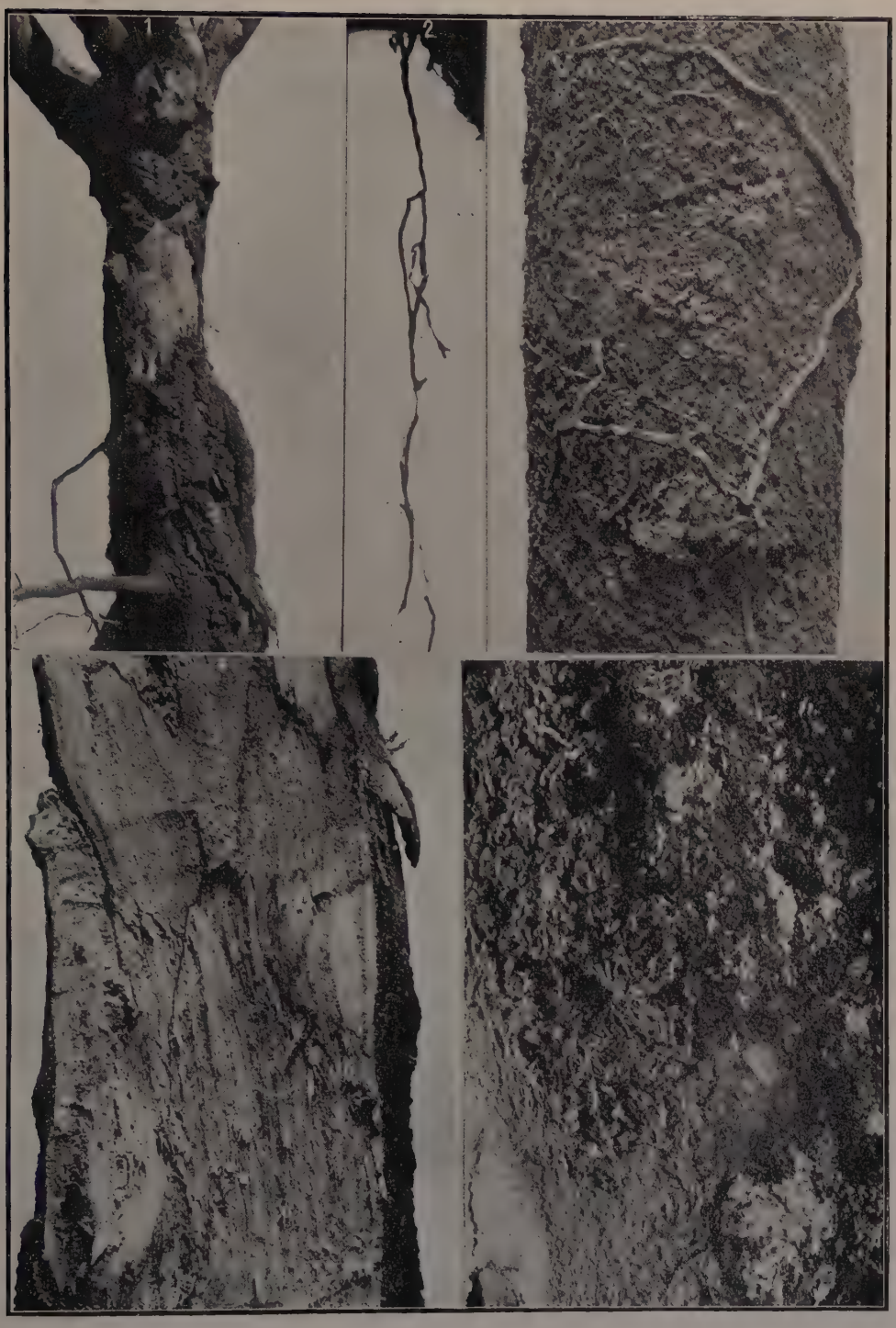


Fig. 1.—Tea bush attacked at the collar by Armillaria showing the fungus on the wood, callus above the region of attack, and rhizomorphs on the root. x1.

2.—A free rhizomorphic stand from a root of *Albizzia lopantha.*

3.—Rhizomorphs on a tea root. x1.

4.—Section through a tea root attacked by Armillaria, showing black lines demarcating areas of different stages of decay. x1.

5.—Tea root attacked by Armillaria showing rough bark on the left and mycelial sheets on the right where the cortex has been shaved away. x2.

demarcated by distinct black lines. In Nyasaland the wood is typically affected by a wet rot—so wet that water can be wrung out of the affected roots. Similar wet rots have been observed in Ceylon in jungle roots infected by this fungus, and in one instance it was reported that when a diseased tea bush was dug out "water or juice poured from the split tap root." Dade [2] considers the wet rot of cacao wood following infection by Armillaria to be the result of the activities of other organisms, possibly bacteria. That the wet rot is due to organisms other than Armillaria is probably correct, as in artificial culture, blocks of tea wood infected by Armillaria show no sign of a wet rot after two years.

The fructification is of the toad-stool or mushroom type. In Europe *A. mellea* is known as the honey fungus owing to its pale-yellow or pale-brown colour. In the tropics sporophores are more rarely found than in temperate zones. The writer has found them but once in Ceylon, at the base of a jungle stump adjacent to an infected tea bush, and then they were too old for accurate description, though he had no doubt that it was the same fungus as that described by Petch under the name *A. fuscipes*.

Armillaria mellea almost always begins life as a saprophyte upon decaying tree stumps or jungle roots. From such centres the fungus spreads to adjacent susceptible plants. Infection may occur as a result of direct contact between the living root and the infected stump, or by means of the rhizomorphs which grow out from the infected stump through the soil to healthy roots at a distance. Infections have been observed to occur directly at the collar of tea bushes as shown in Plate II, Fig. 1. Such infections are unlikely to occur from direct contact with diseased wood and are more likely to be the result of infections by rhizomorphs. When infection occurs at the collar, death results when the bush has been ringed. The development of callus above the region of attack indicates the failure of the fungus to extend its activities in that direction, and also affords some indication of the time which elapses between the formation of a definite lesion and the death of the bush.

As with other root diseases of tea, there is no above ground symptom noticeable until the bush is moribund. Then the leaves rapidly wither, turn brown and fall. Frequently, the death of the bush is the first indication that anything is amiss with the bush. In other cases, the bushes die gradually, generally from one side—the side from which the attack is occurring. In Nyasaland [1] this unilateral type of attack is characteristic of spreading patches, but in isolated cases, where patches are starting, deaths appear to be much more rapid. Whether a bush will die suddenly or slowly from one side will depend upon the virulence of the fungus and the position of

infection. An infection at the collar or on the tap root usually results in an apparently sudden death, whereas an infection on a lateral root, particularly when the advance of the fungus is slow, results in the gradual death of the bush beginning with the branches on the side from which the attack has occurred.

Although the fungus has been known in Ceylon since 1908 the disease was not recorded on tea until 1927, since when it has not become of serious economic importance. A few isolated cases have been observed at high elevations, always in close association with decaying jungle stumps, but in no instance has a spreading patch been found comparable with those reported from Nyasaland or with those caused by the Poria root disease in Ceylon. It would appear that under Ceylon conditions, tea is not very susceptible to the disease. The lack of infection does not appear to be due entirely to the rarity of the fungus, because on certain estates, where *Albizzia lopantha* was tried as a shade tree amongst tea, the Albizzias contracted the disease and died, though in no case, in the writer's experience, did the fungus spread to the tea.

In addition to *Acacia decurrens*, *Albizzia lopantha* and tea, the disease has been found in Ceylon on young Grevilleas growing in close proximity to infected jungle stumps and diseased tea.

Treatment.—Two main points should be borne in mind: (1) the fungus originates from decaying stumps and roots; and (2) the fungus spreads underground by means of black, cord-like rhizomorphs. Because of the former, when diseased bushes are being uprooted a search should be made for the stump or root from which the disease originated. The soil should be well dug over to a depth of about 2 feet and all woody material collected. The roots of adjacent, apparently healthy bushes should be examined, and where found to be infected, the bush should be uprooted. All uprooted bushes, stumps and woody matter collected from the soil should be burnt, preferably on the site. If the diseased material has to be transported to a central place for destruction in an incinerator, it should be carried in closed sacks to prevent any diseased roots being dropped amongst healthy tea. In Ceylon these measures alone have proved effective in controlling this disease, and further losses have been eliminated by their prompt and efficient application.

Where there is definite evidence of a centrifugal spread of the disease as is common in Nyasaland, trenching should be resorted to as an extra safeguard. The trench should be sited so that one row of apparently healthy bushes is included within the isolated area after all dead and known infected bushes have been removed. It should be about 3 feet deep and the excavated soil should be thrown on to the

isolated area and not outside it. The depth of the trench is dependent upon the nature of the soil in which the tea is growing; the trench, however, should have a depth greater than that of the lowest lateral roots of the bushes growing in that soil. The trench should be regarded as an extra safeguard, and not as the primary method of control. It can be effective only so long as it is kept open, which on many sites is a laborious matter.

Where the diseased tea abuts on jungle, a deep trench should be constructed to separate the one from the other to prevent continual reinfection from the jungle.

Control measures should be applied as soon as the disease is observed; delay in their application favours the spread of the disease and results in increased losses.

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A REVERSE SLOPE DRAINING SYSTEM—II.

A. G. D. BAGOT.

The following notes in amplification of the article previously published (*Tea Quarterly*, 1930, **3,** 73). may perhaps be of interest.

Inspection of the drains after heavy rain shows clearly the wide variation in the capacity of the soil to absorb water, some sections holding up water very much longer than sections adjacent to them. It has been noticed, however, that as the sub-soil becomes more thoroughly aerated by the use of these drains, water has been absorbed at a quicker rate. The amount of water held up is, of course, very considerable. Considering 18 in. wide drains with a 12 in. water level, 100 feet of drain will contain 75 cubic feet of water. Assuming there are 1,500 feet of drains to the acre, since 1 c.f. water equals 6·23 gallons, then approximately 70,087 gallons of water per acre are held up to be absorbed at the cessation of rain if the drains have been overflowing. This water contains dissolved air and plant food derived from the surface soil and must find its way through the sub-soil which is thereby definitely improved in condition.

The reverse slope drains in question have now been cut over some 90 acres of pruned tea and have been available for more detailed observation. During the four months of pruning and manuring these fields only 10 inches of rain was recorded but this comparatively dry period was followed by 11·5 inches in a fortnight.

Due to the long spell of dry weather there was a considerable amount of silt brought down into the drains with the first onset of heavy rain and, with the continual daily rain, the drains were not capable of absorbing the water with sufficient speed to prevent them overflowing. Nevertheless, a very considerable amount of silt and loam, rich in the artificial manures recently applied, was collected on the sections along the drains and it was observed, in fact, during the heaviest rain when the sections were spilling, that most of the silt was so retained, little passing over the spills.

The amount of silt so far collected is not sufficient to impair the working efficiency of the drains since, although at first it is inclined to form a heap where it has fallen from the bank above the drain, with the action of the running water it becomes more evenly spread out over the surface of the reverse slope and, until the latter becomes levelled out by reason of the quantity of silt collected, no appreciable quantity of silt is pushed over the edge of the section. The silt so accumulated is, of course, available for return as a top dressing either above or below the drain.

Another advantage observed in the pruned field is that although a certain number of prunings fall into the drains, their presence does not cause these drains to become blocked since the flow of water in them is not powerful enough to carry the prunings along. Hence, the drains, except for the periodical cleaning out of the collected silt, require less attention than drains with a continuous gradient.

On the other hand, further observation has shewn that if any unchecked flow of water is allowed to enter these drains, so causing a more rapid stream to flow over the spills, there is then a certain amount of erosion caused on the top of each section. In such cases, therefore, it is not suggested that these drains will be of a permanent nature unless the lip is reinforced with stone. By the side of a cart road or path, for instance, such drains are useful in collecting the gravel or surface that washes off the roads, which can easily be replaced from the drain, but the excess amount of water arriving from the hard surface of the road is apt to cause these drains to overflow at a quicker rate than they do when cut in the field and hence internal erosion is set up. The importance, however, of holding up as much silt as possible is clearly shewn from the following figures which illustrate the amount of soil lost with ordinary drains.

In a field where the ordinary drains were in existence, a silt-pit 5 ft. × 5 ft. × 5 ft., *i.e.*, of 125 cubic feet capacity, was cut at the botton of each of four leading drains. After three inches of rain had fallen in five days these pits were all filled with silt which had emptied into and out of these leading drains. In other words some 500 cubic feet of soil had been lost in five days from about five acres of land.

Construction of reverse slope drains.—In practice it is not found necessary to find the level of each section separately, but the length of the sections, if made at a 6 in. level, will be half the reading of the gradient of the main drain, *i.e.*, a gradient of 1 in 15 will make the sections $7\frac{1}{2}$ ft. long. If, however, the gradient is less than 1 in 30, the optimum length of 15 feet should not be exceeded, in other words for any gradient less than 1 in 30 use a 15 ft. section. By so doing the height of the water level will, of course, vary with the gradient and the level taken will be less than the original 6 in.

New clearings.—Assuming in a new clearing the drains are already cut with a gradient of 1 in 60, then by cutting 15 ft. sections there will be a drop level of only 3 in., but the height of the water level has been increased to 1 ft. 3 in., thereby increasing the water-holding capacity.

When cutting completely new drains in a new clearing, a gradient of 1 in 120 might be used. Then by cutting 15 ft. sections there will be a drop level of only $1\frac{1}{2}$ in. but the height of the water level will be raised to 1 ft. $4\frac{1}{2}$ in. The water-holding capacity will thereby be

increased to 101 c.f. per 100 ft. of drain and without cutting to any greater depth than the original 1 ft. 6 in., or say 2 ft. allowing for a bund of 6 in. to the drain. Having then a spill of only $1\frac{1}{2}$ in. there is a smaller surface at the edge of each section to be worn away. Although the flow of water may not receive such a check by reason of the shorter fall, the gradient being less steep will help to diminish any rapid flow.

In conclusion, it has been observed that with drains of the type described, even with such a steep gradient as 1 in 10 and with sections only 5 ft. long, during the period the drains are overflowing nearly the whole of the silt is deposited and but little passes over into the adjacent section. This is doubtless due to the fact that the bulk of the silt tends to sink to the bottom of the drain and as this bottom surface has a reverse slope, this acts as a brake on any movement of the deposited silt. Moreover, as the water which passes over the spills is only in a shallow layer, it has less force to push over any solid matter.

TEA FERMENTATION—PART IV.

D. I. EVANS.

THEORIES PUT FORWARD TO EXPLAIN THE FERMENTATION OF TEA.

It was pointed out in the first of these articles that fermenting tea requires oxygen for the process, and that the utilisation of oxygen was accompanied by certain changes in the leaf constituents, especially in the tannin fraction of the leaf. A good deal of time has been given to the study of the mechanism of this action, but it must be acknowledged at the start that work on this subject has not yet clarified the position to any great extent. In previous articles an account has been given of the investigations dealing with the effect of different conditions of temperature, humidity, etc., on the final product without probing very closely into the process step by step. This empirical method of investigating tea manufacture, is of great service, but its limitations prevent the elucidation of the problem as a whole, and a complete control of the process of manufacture cannot be obtained until a good deal more is known of the chemistry of the leaf and of the mechanism which is responsible for the rapid oxidation, and the development of those characteristic properties of black tea.

Certain hypotheses have been put forward to explain how the reactions taking place during tea manufacture occur, and experiments have been carried out to test these hypotheses but, although the results of these experiments were not very conclusive, and the authors generally guarded in stating their conclusions, I find that in many quarters one or other of these unproved hypotheses is accepted as definitely proved, whereas the real position is very indefinite, and

nothing has been proved one way or the other. An attempt will therefore be made to give a short account of some of the experiments carried out, and to demonstrate the real contribution which such work has made towards a solution of the problems concerned. In the meantime, progress will be on surer lines if the question of the mechanism of tea fermentation is approached with an open mind, and adhesion to hidebound conceptions given up in favour of strict observation and careful experiment.

The first speculation concerning the process of tea fermentation contended that it was a putrefactive change, but it was shown by the experiments of van Romburgh, Lohmann and Bamber that oxygen is necessary for oxidation, since rolled leaf could be kept in an atmosphere free of oxygen without undergoing change. Tea fermentation is thus an oxidation of the leaf material and it is possible that this oxidation is set in action as soon as the leaf sap is exposed to the oxygen of the air, *i.e.*, all that is necessary for tea fermentation is to expose the oxidisable material to the air. However, it was shown that temperature was a controlling factor in the process, fermentation being very slow below 40°F, and that heating the leaf to 212°F. rendered the leaf incapable of fermenting on being crushed. This property of the leaf is utilised on those estates where green tea is made, for when the fresh leaf is steamed at 212°F. it will not lose its green colour during the subsequent manufacturing processes. Again the production of colour in fermenting tea is usually accompanied by a development of aroma, but it was shown that although colour production does occur above 113°F, no aroma is developed at such temperatures. The original idea that tea fermentation was a process of putrefaction was thus given up for that of rapid oxidation, and the results of observation of the effect of temperature on the reaction led to the idea that the oxidation was brought about by some agent or agents which are inhibited or destroyed by unfavourable temperature conditions.

Colour production in other plants had been shown to be due to the presence of small quantities of some accelerating principles called catalysts and it was suggested that similar substances were present in the tea leaf. Attempts were made to isolate such bodies from the fresh leaf, and these attempts were successful. This isolation of organic compounds possessing catalytic activity led to the adoption of the idea that tea fermentation is due to the presence of these catalysts, and it is generally referred to as the enzyme action in tea fermentation.

On the other hand it was known that other fermenting processes were due to the action of yeasts, and that other complicated changes were carried out by means of bacteria and fungi. Further, it was known that plant products such as the grape were associated with

their yeasts on the plant, so that when the skin of the grape is punctured, the yeasts come in contact with the juice. This mixing of the two results in a fermenation which is generally accompanied by the development of flavouring and aromatic substances. It is, therefore, permissible to suggest that the same thing occurs when the tea leaf is crushed in the rollers, provided it can be shown that micro-organisms do exist in the fresh leaf, and that their presence or absence can affect the process of fermentation. It was soon shown that micro-organisms were always associated with the tea leaf, but the investigators have not been so successful in their study of the action of these micro-organisms on the fermenting leaf. The presence of yeasts, fungi and bacteria on the fresh tea leaf forms the basis of the argument that tea fermentation is due to the activity of micro-organisms.

It will thus be seen that there are grounds for maintaining either the enzyme or micro-organic theory of tea fermentation, and in the present article a short account of the investigations carried out to test the enzyme theory is given. An account of the investigations concerning the micro-organic theory will be given in the concluding article of the series.

FERMENT OR ENZYME THEORY OF TEA FERMENTATION.

(a) *Enzymes and their general properties.*—According to Waldschmidt Leitz (*Enzyme Actions and Properties* 1928), "Enzymes may be described as definite material catalysers, formed indeed by living cells, but independent of the latter in their operation." The term catalyser requires further explanation to make the above clear, and this is best done by giving an example of what a catalyst does.

Cane sugar is a compound made up of two other simpler sugars, but under certain conditions it will split into the two simpler sugars which compose it. The rate at which it will break down into the simpler sugars is very low in neutral aqueous solutions, but it becomes very rapid if a little mineral acid is added. The acid can be recovered at the end of the reaction unchanged in any way and does not appear to have taken any part in the reaction. Since the same change was going on very slowly in a neutral solution the addition of acid has not started the reaction, but its presence has acted as an accelerator. There are many substances, which possess the property of accelerating chemical reactions without apparently undergoing any change themselves during the process, and the discovery of such substances has been of great value for many industrial processes. This acceleration of any chemical change by means of a foreign substance, which does not start the reaction and does not itself take part in the reaction is termed catalysis, and the substance responsible for the action is called the catalyst.

It was well known that living organisms are capable of carrying out their reactions with ease at comparatively low temperatures, and that some of these reactions could not be reproduced in the laboratory at all, or at least without the application of very high temperatures. It was thus possible that the ease with which living organisms produced these changes was due to the utilisation of catalysts by them.

Plants and animals do actually contain a large number of organic complexes which can act as catalysts, and many of these have been isolated and studied. The plant or animal catalysts are termed enzymes, and they differ from the inorganic catalysts like the mineral acid referred to previously in being sensitive to heat and light. They are all destroyed at 212°F., while many cannot stand a temperature of 140°F., and exposure to strong sunlight in the presence of oxygen often destroys them.

It is not known how these enzymes are formed in the plant, but it was soon discovered that any particular plant generally contains several types of enzymes capable of accelerating different reactions, and among these have been found several groups which are capable of accelerating oxidations. These classes of enzymes are collectively termed oxidases. Their action is often accompanied by colour changes, such as the browning of the cut surface of certain types of apples when exposed to the air, and of the expressed sap of species of *Rhus*. These saps rapidly turn brown and then black on exposure to the air owing to the presence of an oxidising enzyme laccase, and the lacquer industry of China depends on this oxidase activity.

The changes produced during the manufacture of black tea, such as the rapid browning of the leaf when it is crushed, appears to bear some similarity to these colour changes produced in other plant saps, and which were known to be due to oxidase activity. Again the way in which the fermentation of tea responded to temperature conditions was a further reason for suspecting that the action concerned was of enzymic origin, and attempts were made to isolate oxidising enzymes from the tea leaf.

(b) *Early work on the enzymes of tea.*—Bamber (*The Chemistry and Agriculture of Tea* 1893) reports having isolated small quantities of oxidising enzymes from tea and he and Wright give a fuller account of their work in the *Proceedings of the Planters' Association* 1902. According to these two authors the enzyme or enzymes exist in all types of tea, there being no difference in the amount of enzyme found in low-country tea as compared with high grown tea, or in leaf a few weeks from pruning as compared with leaf two years from pruning. Climatic conditions of growth and time of day when the leaf was plucked had no effect on the amount of enzyme determined in the

leaf. Aso (*Bull. Coll. Agric., Tokyo Univ.* IV. 1901.) was also able to isolate a substance from tea leaf which gave the usual oxidase reactions, and which was able to produce a brownish colouration in an alcohol extract of fresh tea leaf. However, although these investigators were able to isolate a substance having the properties of an oxidase, they were not able to report that addition of their enzyme produced any difference on a tea fermentation, and their conclusion that tea fermentation is the result of oxidase activity depends on the fact that they found oxidising enzyme in the leaf. This may be true, but until it has been shown that addition of the enzyme to fermenting tea can produce a difference in the rate of the reaction or the degree of fermentation produced it must be accepted as an unproved hypothesis.

Mann. (*The Ferment of the Tea Leaf and its relation to Quality. Bull. Ind. Tea Assoc.* 1901. *et. seq.*) describes his experiments on the enzymes of the tea leaf. The isolated enzyme had the properties of an oxidase, and it is stated that its addition to fermenting tea leaf produced a normal but quicker browning of the leaf than in its absence. The same change was produced if it was added to tea juice instead of tea leaf, and the enzyme preparation was also able to oxidise other easily oxidised compounds with great rapidity. Mann concluded that the enzymes separated by him from fresh tea leaf did play a part in tea fermentation. He found that a temperature of 160-165°F. maintained for 3 minutes had no appreciable effect on the activity of the enzyme, but that it was destroyed if it was subjected to temperatures above 180°F. for the same period. The enzyme was very active at 130°F., but feeble at 143°F., and because of this Mann points out that it is necessary to fire tea above 150°F. in order to destroy the enzyme and thus check the fermentation. The enzyme, which acted best in a slightly acid medium was destroyed by strong acid or alkali, and could be divided into two components. One of these components gave an oxidase reaction with his guiacum reagent immediately, and was termed the free enzyme. The other component did not give the oxidase reaction until it was mixed with hydrogen peroxide. The oxidase reaction of the enzymes in the presence of hydrogen peroxide was therefore greater than in its absence and this was designated the activity of the total enzyme.

According to Mann the amount of enzyme in the different parts of the flush varied, the greatest concentration being found in the tip and stalk, but this decreased in successive leaves below the tip. On this finding Mann claims that apparently the best tea is produced from those parts where the enzyme is present in greatest amount. If a high concentration of enzyme should give a better tea than a low concentration, then the stalks should give the best tea of all, but

Mann explains away this discrepancy by showing that the relative amount of acidity, tannin and phosphoric acid is so low in the stalks as to account for the poorer quality tea made from them. This argument, however, can be put in another way, with equal justification if not more, *i.e.*, the best tea is made from those parts which contain the greatest quantity of acid, tannin and phosphoric acid. Whether the concentration of enzyme present has anything to do with it or not is not indicated by the figures given.

He states that on examining teas from various gardens it was found that there was a close relationship between the amount of oxidase present and the flavour of the tea, provided other things were equal. No figures are given to show that the other things were equal since the chemical composition of the various teas is not given, and the difference in quality may have been due to a difference in the composition of the tea. Mann himself (*The Tea Soils of Assam and Tea Manuring* 1910) says that a large amount of phosphoric acid must be present in the soil for the production of good quality tea, and that phosphoric acid is present in greater quantities in good than in poorer quality leaf. At the same time it is clear from Mann's data that a high enzyme content is not always associated with a high phosphate content since a high enzyme content is associated with a low phosphate concentration in the stalk. The few results given are not enough to draw any conclusions relative to this point, but in justice to Mann it must be said that he was aware of the fallacy in the argument, and ends his paper by saying that it is very doubtful if it would ever be possible to improve the flavour of tea by the addition of prepared enzyme, since the action of the enzyme itself depended on the presence of the material to be changed, and because the nature of the substances responsible for flavour were not known.

In his second paper Mann describes the effect of withering on the amount of enzyme to be determined in the leaf. It appeared from the results of previous experiments as if the quantity of enzyme increased as a result of withering, and on carrying out further experiments the results obtained supported this contention. Thus in one experiment carried out at a temperature between 76°F. and 86°F. he obtained the following results:—

Relative amount of Enzyme present in withering leaf. (Mann).

Time leaf was withered		Active Enzyme.		Total Enzyme.
1 hour	...	1·00	...	1·00
5 hours	...	1·14	...	0·96
18½ ,,	...	1·71	...	1·77
23½ ,,	...	1·29	...	1·38

The leaf used for the experiment was deemed to be properly withered at about 18-hours when the enzyme seemed to be present in maximum amount, and the conclusion arrived at that a proper wither

is obtained when the correct physical wither corresponds with the maximum development of enzyme in the leaf. The author gives no indication of his criterion of a proper wither as judged by empirical methods, but if the 18-hour wither he obtained was the 70 per cent. usually favoured in India, then his leaf was very different from the 55 per cent. withered leaf found to give excellent results in Ceylon.

In other experiments Mann investigated the effect of period of wither, light conditions during growth and withering, and the time of plucking on the concentration of the enzyme. His conclusions were:—

(a) During withering the amount of oxidising enzyme or ferment increases up to a certain point corresponding under normal withering conditions with the point at which the leaf is ready for rolling.

(b) The two processes of loss of moisture and production of ferment by no means necessarily take the same length of time, and the leaf may be withered (in very dry weather) long before it is chemically ready to roll, and in very wet weather may be ready chemically to roll long before it is withered.

(c) At the temperature studied (76°F. to 86°F) the normal time which the leaf requires in order to be chemically ready for rolling is 18 to 20 hours with normally withered leaf, and several hours longer (it may be up to 25 hours) with leaf prevented from withering by a very wet atmosphere.

(d) Leaf withered in the light contained a little more enzyme than leaf withered in the dark.

(e) Leaf plucked in the morning contained more enzyme than leaf plucked in the evening.

Although Mann's conclusions regarding the best period of withering may agree with practical experience (it is doubted whether this is really true) the data given are not sufficient or accurate enough to substantiate his conclusions. It is not quite clear whether the figures for the total enzymes bear any relation to those for the active enzymes or not, and nothing is said about the variation found with different samples of leaf. The data for active enzyme and total enzyme vary so irregularly and the actual differences found are so small that it is doubtful whether his results are anything more than chance variations. It would appear as if the sampling error was very great from the figures given for the two samples of leaf plucked in the early morning, where one contained 3·37 and the other 1·29 of enzyme, and yet the differences found in the withering experiments were very much less than this. It is impossible to place any reliance on the data obtained by means of methods which are liable to such errors, and much as we would like to accept Mann's conclusions, it is to be regretted that they are not justified by the data he reports.

In his third pamphlet (1904), Mann reports the results of his practical experiments to test the above conclusions. There are three sets of experiments recorded, one of these appeared to support his hypothesis, one was not very satisfactory, and the other proved nothing at all. In spite of this the author claims proof of his theory concerning the time necessary for withering. When his method of experimentation is considered it will be seen that the results he obtained could be easily ascribed to other factors than time. Thus one set of experiments was carried out with four maunds of leaf in the following way:—

No. 1. Ordinary wither with leaf brought in at noon, spread on chungs, rolled at 6 a.m., leaf withered to 64 per cent. in 18 hours.

No. 2. Leaf spread *4 inches deep*, left for 18 hours and then spread in a *"high temperature house"* and quickly withered in 4 hours. This leaf was withered to 70 per cent. in 22 hours.

No. 3. Leaf spread in the same way as No. 2, but withered slowly from 6 a.m. onwards. This leaf was withered to 70 per cent. in 26 hours.

The results of tasting were as follows: "The ordinary wither was slightly, though very slightly, preferable in flavour and liquor. No. 2 (22 hours) gave slightly thicker and fuller liquors than No. 3, and the out-turn of leaf was slightly brighter. The difference, however, between No. 1 and No. 3 was very slight in any point." In each case they were described as giving, "a full brisk pungent liquor, good coppery infusions." Yet No. 3 was only withered to 70 per cent, while No. 1 was withered to 64 per cent, and No. 3 had taken *8 hours longer to wither than No.1*. The slight difference found, if any, may have been due to the thicker spread, or the lighter wither, and these disturbing variations in the conduct of the test make it impossible to draw any conclusions as to the effect of time on the condition of the withered leaf.

The results obtained from No. 2 cannot possibly be used to draw any conclusions as to the effect of time of withering on the quality of the made tea, because the deciding factor in this experiment was evidently temperature and not time. Having retarded the wither for 18 hours by resorting to thick spreading, the leaf was placed in a high temperature house and quickly withered in 4 hours. The actual temperature in the house is not recorded, but the mere fact that the leaf was subjected to a higher temperature than the others during the process of withering is sufficient to rule this experiment out of court right away as a test of the effect of time on withering.

In another set of experiments the leaf was withered to 67·4 per cent in 5 hours at a temperature of 100°F. It is no wonder that the resulting tea gave "a thin, dull liquor, almost sour," but it cannot be

said that this test contributes much to the problem of the proper time required for withering, because the temperature is the controlling factor. The obvious conclusion from this experiment is that when high temperatures are used to wither the leaf in a very short time, then loss of quality will occur to a marked extent, but it does not show what would happen to quality if the leaf was withered to this extent in the same period as a result of the use of drier air at a low temperature. If the above conclusion is true it is useless to try and wither large quantities of leaf by means of a withering machine in a short time, because such machines depend on a high temperature to produce their withering effect.

It is a pity that Mann does not report any experiments with leaf withered during a period ranging between 5 and 18 hours, or 26 and 48 hours. It is possible that the longer period would not have been practicable under the conditions he had to contend with, but this period is of great interest to Ceylon planters many of whom prefer to prolong their wither as long as 48 hours rather than resort to any hot air. The results obtained with these long withers have proved excellent in many cases, but this is not universally true, and it cannot be generalised that a long wither is better than a shorter wither, because excellent teas have also been produced with leaf withered in a short period. These experiments of Mann, however, do not supply any evidence in support of his contention that the enzyme increased during withering and that the proper period of withering should coincide with the maximum production of enzyme.

(c) *Recent work on the Enzymes of Tea.*—In spite of the failure of Mann to prove his theory of enzyme action as a cause of tea fermentation, the idea still persists that the oxidising enzymes found in the tea leaf do play an important rôle in tea fermentation. Bernard and Welter (*Annales du Jardin Botanique de Buitenzorg* 2e Serie. X. 1911) in Java reinvestigated the methods of isolating these enzymes with a view to obtaining a purer product than had been isolated so far for studying their properties, but this work is too academic in character to be fully dealt with in the present article.

On repeating Mann's method of preparation they found that all the tannin could not be removed by the use of hide powder, and that the guiacum reaction used by Mann to estimate his enzyme concentration could be produced by other substances than the enzyme. Thus scratches on the reagent glass, the presence of sand, pumice stone or any fine powders produced the same effect on the guiacum reagent as the enzyme did, and the method becomes very difficult to apply in a quantitative way. The conclusions they arrived at as a result of their very extensive investigation were:—

(1) No practical or theoretical conclusions of importance can be drawn from the investigation.

(2) Peroxidase (Mann's combined enzyme) can be found in every part of the plant, but oxidase in the true sense of the term is not found.

(3) Nothing could be said concerning the action of the enzyme on flavour or aroma.

Deuss (*Chemisch. Weekblad* XX. 19. 1923.) gives a short synopsis of the investigations into the part played in tea fermentation by oxidising enzymes, and gives the facts which had been demonstrated by the experiments without further comment or discussion, as he considers that would have been premature considering the incomplete knowledge of these enzymes. Although each stated fact was tested ten times and carried out with controls, Deuss does not commit himself more than to say that it is not known how far the tea ferment or ferments are necessary for the production of black tea.

The salient points of these investigations are that no pure preparation of the enzyme or ferment has yet been prepared, and that although an aqueous solution of the most pure product obtained reacted neutral, it was not free from tannin. The presence of the tannin makes it very difficult to investigate the action of the enzyme, and if the tannin is removed by precipitation with lead acetate the enzyme solution becomes inactive. The enzyme, which contains nitrogen, sulphur, phosphorus, manganese, magnesium, potassium, iron and albumin loses its solubility in water when dried and kept in a desiccator for a long time. The reaction between the enzyme and a guiacum solution is very slow between 32°F. and 50°F., strongest at 113°F. and slow again at 169° to 190°F., while boiling for 1, 2 or 3 hours renders the enzyme inactive.

Deuss' paper is a fair account of the facts known concerning the oxidising enzymes found in the tea leaf, so that the true position appears to be:—Oxidising enzymes are present in the tea leaf, and one of the reactions which takes place during tea fermentation is an oxidative change, but what rôle the enzymes play in the oxidative change or what effect the various processes of manufacture such as withering have on the enzyme in the tea leaf is not known.

Although Mann's work on the enzymes and the effect of withering on the concentration of these organic catalysts in the leaf has been criticised rather severely it is not suggested thereby that the quality or the nature of the tea produced is not affected by the manner of withering. On the contrary the evidence gleaned from practice supports the contention that the period of withering is undoubtedly very important. At the present moment, however, it is difficult to apportion the effect produced between the various factors concerned, such as a difference in the quality of the fresh leaf itself, moisture content of the fresh leaf, actual moisture content of the withered leaf,

temperature conditions during withering and the duration of any period of high temperature. Again the diversity of opinions concerning withering may be due to a possibility that, with certain kinds of leaf and at particular seasons, better results may be obtained by extending or shortening the withering period so that the idea of a best time for withering cannot be upheld, and he who dogmatises on such questions is very liable to fall into error.

(*To be concluded*).

MANURIAL EXPERIMENTS ON NITROGEN, PHOSPHATE AND POTASH.

(REVIEW)

The General Experiment Station of the A. V. R. O. S. in Sumatra has recently concluded a series of field trials on the Haboko Estate [1] using replicated treatments with a view to obtaining a higher standard of accuracy than is attainable where only one or two plots of each treatment are used. The paper under review gives results of experiments devoted to the effects of nitrogen, phosphoric acid, and potash manuring, an account of the technique employed and the advantages it entails.

The work is of interest from two points of view; firstly, the purely technical side which is of importance to other scientific officers engaged in similar investigations; and secondly, the practical side which appeals to both the experimentalist and the agriculturist. The account which follows deals with both these outlooks, and for the convenience of the non-technical reader they are dealt with separately, the agricultural considerations being dealt with in Part II.

1. METHOD OF EXPERIMENTATION.

The field experimental method used in these trials is put on record as a first attempt to deal with a number of problems, including soil heterogeneity, variation in plucking capacity and interference of climatic conditions, which affect the apparent yields of leaf collected in the field. A typical experiment (H5) may be taken as a basis for discussion. The arrangement of the plots is given on next page. The yield figures over twenty months are given as half-kilogrammes. The treatments are labelled according to the following scheme:—

a = unmanured.
b = nitrogen 30 lb. per acre + phosphoric acid 30 lb. per acre.
c = nitrogen 30 lb. per acre + phosphoric acid 30 lb. per acre + potash 30 lb. per acre.

Each plot received two applications with a year's interval between.

I	II	III	IV	V	VI	Totals
1534 a	1823 c	1453 b	1580 a	1714 c	1659 b	9763
1515 b	1410 a	1375 c	1425 b	1373 a	1331 c	8429
1691 c	1678 b	1441 a	1782 c	1763 b	1415 a	9770
4740	4911	4269	4787	4850	4405	27962

An examination of the design of the experiment shows that each treatment occurs once in each of the columns numbered I-VI and twice in each row. The columns were made the basis of the plucking task so that with different teams of pluckers picking different columns, a difference in plucking capacity between them will not disturb yield comparisons between treatments in the same column. It is an advantage thus to eliminate the possibility of error from variable standards of plucking amongst the coolies though the results of the Nuwara Eliya uniformity trial to be published shortly indicate that under our conditions the variation is not serious. In order to counteract errors arising from the variations in the amount of extraneous moisture adhering to the leaf in wet weather, the columns were plucked in opposite directions alternately. This device is the only palliative available if sampling for dry weight determinations is not adopted. It does not altogether meet the requirements as it cannot allow for rains at various times of day.

It is noticeable that the column totals vary despite their similar treatments; such variation is accordingly caused by soil or bush heterogeneity, and in order to eliminate this type of variation from the calculation of errors, the so-called "Student's" method of comparison was used. This consists of comparing plots within the same columns thus:—

I b - I a
II b - II a
III b - III a

and so on. The error is then calculated from the discrepancies in the resulting figures. This device ensures that differences in columns which do not enter into the treatment comparisons shall not artificially increase the error. A similar variation in fertility is apparent for rows as well as columns, and since each treatment occurs twice in each row a similar method might have been employed there. This possibility has

been overlooked, for the paper states: "It is not possible however to eliminate their influence, (*i.e.*, that of fertility gradients) altogether since in this instance differences in yield occur in two directions perpendicular to each other." "Student" himself has pointed out [2] that his method can be extended so as to eliminate fertility gradients in more than one direction and that his solution is more simply and adequately performed by Fisher's analysis of variance [3]. The method consists of taking the row and column totals and using their deviations from the mean total as a measure of their contribution to the total variability of the experimental results as a whole. The analysis for experiment H5 is as follows:—

Variance due to	Sum of Squares of Deviations	Degrees of Freedom (n—1)	Mean Square Deviation.
Treatment	84704	2	42352
Rows	198770	2	99365
Columns	113182	5	22636
Remainder	38943	8	4868
Total	435599	17	

The results show strikingly how much disturbing effect is due to soil heterogeneity in rows and columns. It is particularly noteworthy that the row heterogeniety as measured by the mean square deviation is more serious than that of the columns. The method applied in the original publication thus removed only the lesser of the two evils.

The variance labelled remainder is that from which the standard error is derived and relates to all treatment comparisons. It has the further advantage of being derived from eight degrees of freedom instead of five by the application of "Student's" method. From this remainder variance the appropriate calculated standard error of a difference between two means is 40·3 which for the experiment as a whole represents an increase in accuracy.

The next step in the examination of method is to consider the mean differences in relationship to error. In the following tables the results arrived at by the two methods outlined are set out side by side; errors by "Student's" method are quoted from the original paper:—

Treatment Comparison	Difference	Student S. Error	Student *t*	Fisher S. Error	Fisher *t*
b-a : Nitrogen/phosphoric acid—unmanured	123	35·5	3·47	40·3	3·05
c-a : Complete manure—unmanured	160	70·0	2·28	40·3	3·97
c-b : Complete manure—Nitrogen/phosphoric acid	37	65·0	0·57	40·3	0·92

In addition to the actual error value, that of the statistic *t* is included in order to test the significance of the results; *t* being $\frac{\textit{mean difference}}{\textit{S.E. of mean.}}$

The value of t that has been largely used in statistical computation as indicating real and significant differences is 2. Since the first two comparisons are claimed to be absolutely reliable on the basis of "Student's" method, this value has evidently been used here. It is not always realised that $t=2$ is an adequate criterion of significance only when the error calculation is based on a large population. As the number of comparisons decreases, the value at which t becomes significant increases. Fisher (*loc. cit.*) publishes tables showing how the significant value of t changes. For the probability that a result would appear significant once in twenty times, when in reality it is due to chance, the following are some of the values:—

(n-1)	4	5	8	10	20	infinity
t	2·776	2·571	2·306	2·228	2·086	1·960

The criterion in this experiment for errors computed by "Student's"-method is $t=2{\cdot}571$; for those by Fisher's method $t=2{\cdot}306$. These values throw some doubt on the reliability of gains due to treatment (c) according to the first method, but with the fertility slope interference eliminated in both directions, as in Fisher's method, the superiority of treatment (c) is confirmed. It may be pointed out that a non-significant result for comparison (c-a) gives rise to an anomalous result, since it is unlikely that where nitrogen and phosphoric acid (b) is successful, nitrogen, phosphoric acid and potash (c) should be unsuccessful. The failure of "Student's" method is here due to the trough of low production caused by the middle row. By Fisher's method the results are completely intelligible: both nitrogen plus phosphate and the complete manure give significant increases, but the apparent superiority of the latter is not great enough to be relied upon.

It remains now to consider the practical bearings of the whole of the experiments. In so doing the more accurate criterion of t just mentioned will be applied to the results.

II. PRACTICAL RESULTS.

Table I gives a summary of the results of the five experiments. These have been expressed in pounds per acre fresh leaf for the purpose of this review: reliable results are printed in heavy type. The standard dose for all nutrients is 30 lb. per acre, which in manurial equivalents is equal to 150 lb. of sulphate of ammonia, 164 lb. superphosphate and 60 lb. sulphate of potash. Some treatments involve a double dose of one nutrient.

TABLE I.

Yield increases in lb. per acre fresh leaf for various treatments under varying conditions.

Increase due to	2 applications D3	2 applications H5	1 application F5	Complete followed by treatment A2	Treatments followed by N and Phos. H4
N				657	288
N + Phos.	**1285**	**344**	**316**	536	277
N + 2 Phos.				**670**	486
2N + Phos,				**1035**	
N + Phos + Pot.	**1570**	**447**	**410**		
Potash	288	103·5	95		

Figures in heavy type are statistically reliable

The first three experiments D3, H5, F5, are similar but, whereas D3 and H5 were given two applications of manure at intervals of a year, F5 received only one application five months after the commencement of the experiment. The addition of nitrogen and phosphoric acid in all cases gives a reliable increase. The further addition of potash (making a complete manure) gives an increase over the nitrogen plus phosphate which cannot be considered reliable even when the results of all three experiments are pooled. These experiments give no indication as to whether nitrogen or phosphoric acid or both nutrients are responsible for the increase.

Experiment A2 shows the result of giving different treatments six months after the application of a complete manure. The addition of a single dose of nitrogen after a complete manure gives no reliable increase and the same applies to additions of nitrogen plus phosphate in single doses. The results when double doses of either phosphate or nitrogen in the presence of a single dose of the other is applied show a reliable increase. Such a result is difficult to interpret since the previous comparisons suggest that the preliminary application of a complete manure has met the nutritional requirements for the whole period. The explanation appears to be that the section of the experiment devoted to double doses occupies more uniform land than that assigned to single doses since, in point of fact, the errors are much lower. It is again impossible definitely to decide whether nitrogen or phosphoric acid or both are responsible for the increased yields.

Experiment H4 gives the combined results of various treatments followed six months later by a uniform application of nitrogen and phosphoric acid. The author remarks on the unsatisfactory nature of the experimental ground. An examination of the results on the stricter lines dealt with in Part I indicates that none of the results is reliable.

Considering the series as a whole, it appears that a combination of nitrogen and phosphoric acid gives reliable results when compared with land unmanured, and that further increases of yield probably occur from the use of additions of these two manures six months after a complete dressing. We cannot, however, agree that nitrogen has always given satisfactory results, nor that the increase due to potash is real.

The paper mentions that these experiments followed and were designed on the basis of extensive analyses of the Haboko Estate soils and yields at the Rothamsted Experiment Station. The writer of this review took some part in these investigations, the results of which indicated a correlation between phosphoric acid content in the soil and yield. The experiments here outlined fail to follow up that finding since only one direct test of phosphate is included and this gives negative results. They, however, indicate that the results of soil analyses in the absence of related field experiments must be accepted with reserve.

T. EDEN

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(2) 'Student'—*On Testing Varieties of Cereals*, *Biometrika* 1923, **XV**, 271.

(3) Fisher, R. A.—*Statistical Methods for Research Workers*, 3rd Edition, 1930.

QUARTERLY REPORT ON THE WORK OF THE SCIENTIFIC STAFF, TEA RESEARCH INSTITUTE.

Thirty-six consignments of diseased plants were received for examination by the Mycologist during the quarter under review. Thirty-two of these were tea specimens of which thirteen proved to be root diseases.

Further cases of the Acacia root disease mentioned in the first quarterly report have been investigated by the Mycologist. These were obtained from another district, but the same species of Aglaospora was found on the roots. This species is quite distinct from *A. aculeata* which causes a stem disease of tea. The fungus has been isolated and when inoculated on a young, healthy Acacia plant caused its death. Unfortunately, the fungus was not recovered from the infected plant, so proof of parasitism is not complete. As this is the only fungus of those isolated from diseased Acacia roots which has caused any disease in the inoculated plants, there is *prima facie* evidence that this species of Aglaospora is the causal fungus.

The Branch Canker caused by *Physalospora* sp. which was referred to in the last quarterly report has now been found on tea in plucking. In this case also only immature fructifications have again been found. It causes cankers in some instances like those of Macrophoma, but in others the fungus progresses as a dieback.

Armillaria root disease has been found on Grevillea. The occurrence of this root disease in a field of young tea in the Nuwara Eliya district has enabled further observations to be made of its occurrence in Ceylon. The disease invariably originates at old stumps and roots, and infection occurs not only by contact but at a distance by means of rhizomorphs. The uprooting of diseased bushes and the removal of the infecting roots have so far afforded complete control without the construction of trenches. The disease appears to be more readily controlled under Ceylon conditions than is apparently the case in Nyasaland or the Dutch East Indies.

Investigations into the fungus flora of a compost heap have been continued by the Mycologist. It is of interest that *Rhizoctonia batatícola* proved to be a common fungus in the heap and that it readily breaks down cellulose. This fact accounts for its prevalence in Ceylon soils and offers some explanation of its prevalence on dead roots without assuming parasitism. In all probability, it plays an important part in breaking down dead vegetable matter and in the formation of humus. In this respect its action must be regarded as beneficial.

Complaints have been received from one district of the poor quality of the seed crop this year as shown by the large proportion of light seed. In one case examined, the seeds when shelled had the appearance of old seed though they were freshly gathered. The moisture content of the cotyledons was found to be 16·2 per cent. as against 37·5 per cent. of other seed 3 months old but stored in a sealed tin. These figures indicated that the seed has dried out before being shed. This conclusion is supported by the fact that the shelled seed on being soaked in water take up a normal appearance and texture.

In another case, at least 36 per cent. of the seed collected were not normally developed. Some seed were entirely empty; others, which had apparently developed normally in so far as the formation of differentiated germ and cotyledons was concerned, failed to fill more than half of the volume enclosed by the shell. This resulted in very light seed and poor germination.

No organism, either fungus or insect, was concerned in the causation of this condition. It is apparently due to climatic and cultural conditions.

Comparatively few specimens have been sent in to the Entomologist and most of those received were mites as is usual at this season of the year.

The breeding experiments with Trichogramma have yielded so far one interesting and important result. It has been found that the size of the parasite varies with the size of the egg from which it emerges, and that this is mainly due to the variation in size of the abdomen. This latter feature appears to be correlated with the number of eggs that the parasite is capable of laying. Thus, parasites derived from the eggs used for breeding average 12-15 eggs per female. Those bred from the eggs of Tortrix, which are larger, average from 25-30 per female, while those emerging from larger eggs still have registered as high as 60 eggs per female. On the other hand, parasites from *Sitotroga* eggs, which are very small, have a very low reproductive capacity. If we could acquire another and smaller species of Trichogramma, we should expect a higher reproductive capacity, provided it reacted in the same way as the native species. The parasite used in America for breeding, *T. minutum*, is reared satisfactorily in the eggs of Sitotroga, and is therefore probably a little smaller than ours; and a European form, *T. evanescens*, averages about 70 eggs per female when bred in the eggs of *Ephestia* sp., a very common flour moth. Efforts have been made to obtain these two species for trial, but so far without result. However, through the kind co-operation of Mr. G. H. Corbett, Government Entomologist of the Federated Malay States, it has been

possible to obtain some live specimens of *T. nana*. These are now being tried under the same conditions as *T. erosicornis*. The thanks of the Institute are due to Mr. Corbett for the trouble he has taken in this matter.

The egg masses of the Tea Tortrix reached a maximum during the quarter in accordance with expectation. Those collected at Mahanilu and Mahagalla estates showed an increasing percentage of parasitised masses, rising from 1 per cent. to 10 per cent. up to the middle of September, when collection ceased owing to the falling off of the numbers of masses available. Collections from elsewhere showed hardly any parasitism at all. It might be added that small liberations of parasites were frequently made in the abovenamed estates.

Sixty-six consignmnts of nettle grubs, exclusive of the collections made at Gonakelle, were received by Mr. Austin during the quarter under review. The majority of these collections came from Passara Group.

On Gonakelle nettle grubs were practically in abeyance during July and August. Towards the end of August an outbreak occurred in an old field due for pruning shortly. The opportunity was taken to make a few insecticidal tests. But within a fortnight of the attack being detected, wilt invaded the field and, in spite of the dry weather prevailing, brought on a considerable reduction in the number of nettle grubs. This was, of course, very favourable from the estate's point of view, but from the point of testing the efficacy of insecticides under field conditions, was rather disconcerting. At times it was difficult to determine whether mortality was due to wilt or to the toxicity of the insecticide under experiment.

A small collection of nettle grubs received from the Pussellawa district showed that at least three species of nettle grubs (*Parasa lepida*, *Thosea cervina* and *T. recta*) were present on the estate attacked. The predominating species was *Parasa lepida*, the blue striped nettle grub. These grubs are gregarious in their habits and confine their depredations to a few bushes which they completely defoliate before migrating to other bushes. Their larval period must be a very long one. The rather large sized grubs which were received from Pussellawa on the 18th of July commenced to pupate on the 5th of September. None of the three species of nettle grubs received showed signs of parasitisation.

In the insectary it was possible once again to raise a few broods of *Natada*. Wilt did appear but the damage caused was negligible compared with that brought on earlier in the investigation.

Attempts to breed the two species of Thosea were not very successful. The larvae can be bred, but the difficulty is to get the female moths fertilised so that they can oviposit. Eggs are deposited promiscuously on the sides of the cages or foliage offered, and the receptacles holding the foliage, but such eggs never hatch. The pupal period appears to last several weeks, at least a month. Nothing has ever emerged from the cocoons constructed when larvae are pupated in captivity, and it has not been possible to find any cocoons in the field. Attempts are, however, being made to induce favourable pupation under insectary conditions.

Narosa conspersa one of the "gelatine grubs" belonging to the family Limacodidae, to which nettle grubs belong, has recently attracted attention by its presence along with the nettle grub. The damage it causes is similar to that of the nettle grub. Its bionomics were studied during the quarter. The grubs pupate on the foliage and the cocoons are quite conspicuous.

Spatulifimbria castaneiceps, a rather small species of grub allied to the nettle grubs, but without urticating hairs, has appeared occasionally with *Natada*. The grubs are soft bodied and of a dark red or even chocolate colour and are to be found on the upper parts of the bush. Cocoons, which resemble those of *Narosa*, are considerably smaller and are conspicuous whitish, globular objects on the upper surfaces of leaves. Moths emerge at dusk and are exceedingly active; a few are under observation in the insectary.

Heterusia cingala, "Red Slug" (Zygaenidae) though not a nettle grub is sometimes associated with these insects owing to their similarity in habits. The damage is practically the same—defoliation and especially of mature leaves. Fortunately these larvae are effectually controlled by a bacterial disease and the Tachinid fly *Exorista heterusiae*. Recently larvae have been parasitised by a species of Apanteles. This appears to be a new observation.

Parasites.—For the successful propagation of nettle grub parasites it is necessary that some alternate host be found on which the parasites can be bred when their chief hosts are non-existent. During the dry season it has not been possible to find any suitable caterpillars which are sufficiently attractive to both *Rhogas* and *Apanteles*, the two potential parasites of nettle grubs with which it is hoped to carry out further work. *Fornicia ceylonica*, also a Braconid, which was at one time considered to be a specific parasite of *Natada*, has recently been bred from both *Thosea cervina* and *T. recta*.

Insecticides.—In addition to the insecticides enumerated in the previous reports the following were tested during the quarter: Nicotine spray, Nicotine oleate, Tephrosia solution, Nicotine dust, Sulphur and Cyanogas, Calcium Cyanide "A" dust.

Nicotine oleate at the dilution tested gave very disappointing results. Tephrosia solution was made from the foliage of the leguminous shrub *Tephrosia vogelii* grown in the compound. The spray was effective. The efficacy of the Sulphur and Nicotine dusts was questionable owing to the high mortality caused by wilt. Cyanogas was not tested sufficiently to warrant a statement as to its efficacy.

Two types of hand dusters or dusting machines were tested—a bellows type and a fan type. The former was more satisfactory than the latter.

During the quarter several visits have been paid by the Biochemist to estate factories to collect data in regard to the humidification of rolling and fermenting rooms. Speaking generally it may be said that, while satisfactory humidification was obtained by the systems examined, as shown by the differences between the wet and dry bulb temperatures, there was evidence of insufficient ventilation with the result that the wet bulb temperature inside the room may be higher than that of the outside air.

Control determinations have now been taken up of the moisture content of the fresh leaf entering the St. Coombs factory, the effect of rolling on the break up of the leaf, and of the conditions obtaining under natural and artificial withering. The data obtained show clearly the unevenness of artificial as compared with natural withering and also the lack of uniformity which exists in any particular loft as a result of position, pure and simple. Air speeds in the lofts have been determined which show that the uneven wither is due to the formation of air pockets with resulting differences in air movement. These results when complete should be of considerable value when considering the design of withering lofts.

Dr. Evans has also continued the leaching experiments with withered leaf. The results confirm those given in earlier reports. Experiments have now been commenced on the respiration of the leaf during withering, but these are not sufficiently advanced for discussion.

The Agricultural Chemist has been chiefly engaged in field work. During the current year the land set aside for the potash and nitrogen manurial experiment has been plucked at 10-day intervals as a uniformity trial. The main object has been to train the pluckers in the management of the experimental plots prior to the commencement of the experiment proper. The yields from the eight occasions have been examined with a view to gaining information as to the nature of the land in use.

The six blocks of nine plots each show marked differences in yield capacity. This is no bar to the usefulness of the areas since the experimental design allows for this fact. Within blocks, however,

there is serious heterogeneity. In view of the present condition of the field, its lack of cultivation and its run-out nature, there is reason to hope that a considerable increase in accuracy will be attained after pruning. For comparisons between the effects of varying quantities of nitrogen and potash, a sufficient accuracy has already been attained, but the present results leave much to be desired in the case of comparisons between the different kinds of nitrogen.

A series of nursery beds for green manure cover crops has been prepared and fifteen varieties have been sown. Difficulty in obtaining seed has curtailed the initiation of the full programme but renewed efforts are being made to secure supplies.

The Plant Physiologist has been engaged in a study of the establishment of transplanted seedlings. Metrical observations on root and leaf development, etc., have been made while all material has been preserved for chemical investigations of the tannin, nitrogen and carbohydrate content. Such measurements suffice to show the type of progress that is made by the plants (2-year-old seedlings). Leaf growth does not appear to be dependent upon previous root growth, though this always occurs, since if this were the case, a longer lag would be expected than actually occurs between the commencement of root growth and the production of leaves from dormant buds low down in the stem.

The origin of new fibrous roots is of interest. After the check administered by planting, all fibrous roots appear to undergo morbid changes though still remaining alive. Their appearance does not, however, suggest that they are active in absorption. New fibrous roots most frequently appear at the finer end of the tap root, a result which suggests that the practice of "tailing" when planting stumps may be a mistake.

Observations have also been carried out on the germination and growth of tea seedlings from shelled and unshelled seed. The data are not yet complete but clearly show the acceleration in germination and growth produced as a result of using shelled seed. In the four months for which figures are available, the plants from unshelled seed have made less than half the growth of those from shelled seed.

ROLAND V. NORRIS,

Director.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

A meeting of the Board of the Tea Research Institute of Ceylon was held in the G.O.H., Colombo, on Wednesday, October 1st.

Present.—Mr. R. G. Coombe (Chairman), the Hon. Mr. D. S. Senanayeke, Mr. A. G. Baynham, Mr. F. F. Roe, Major H. Scoble Nicholson, Messrs. J. D. Finch Noyes, G. R. Whitby, John Horsfall, Jas. Forbes (Jnr.), T. B. Panabokke, R. R. Muras (Acting Assistant Secretary) and by invitation Dr. R. V. Norris (Director, Tea Research Institute.)

Letters regretting inability to be present at the meeting were received from the Colonial Treasurer and the Director of Agriculture.

FINANCE.

Referring to the accounts to the end of August, the Chairman stated that he had gone carefully into the financial position to the end of the current year. He anticipated that there should be a small balance in hand to carry forward to next year, after paying for all building work now nearing completion. The second instalment of the loan from Government, he stated, had been paid a few days prior to the meeting.

The accounts were approved without further comment.

INCREASE OF TEA CESS.

A letter from the Colonial Secretary was read stating that the proposed alteration to the Ordinance had been approved by the Executive Council, and a draft of the Ordinance was now being published in the "Gazette" prior to the matter coming up before the Legislative Council.

ESTIMATES SUB-COMMITTEE.

On the motion of the Chairman, the Board appointed the following to constitute a Sub-Committee, to consider the draft estimates for 1931: the Chairman, the Director, Tea Research Institute, the Superintendent, St. Coombs, Mr. F. F. Roe and Mr. John Horsfall.

MEMBERS OF THE BOARD.

The thanks of the Board were recorded to Mr. A. S. Collett for his services during Mr. Finch Noyes' absence.

BUNGALOWS—ARCHITECT'S REPORTS Nos. 15 AND 16.

The Director reported that two of the senior staff bungalows had been taken over at the end of September, and Dr. Evans was being transferred to St. Coombs that week. It was anticipated that the

two remaining bungalows would be completed by the end of November. Progress was now satisfactory, and the work would be finished under the contract time. The contractors had also made good the defects in the Superintendent's bungalow, and during the recent bad weather no further trouble from leaks had been experienced.

ST. COOMBS ESTATE.

Layout of Grounds.—At the request of the Chairman the Director informed the Board that he had been able, through the courtesy of the Director of Agriculture, to secure the advice and assistance of Mr. Parsons in the laying out of the grounds. Mr. Parsons had already paid one visit and arrangements had been made for supplies of hedge cuttings, ornamental shrubs and trees. It was hoped to have the work completed before the Conference in February.

The Chairman expressed the Board's appreciation of the help given in this matter by the Director of Agriculture and Mr. Parsons.

VISITING AGENT'S REPORT.

The Chairman explained that the present report had been made by Mr. Baillie-Hamilton, owing to Mr. Ferguson's absence on leave. The report was a satisfactory one and had been considered on the previous day by the Experimental Sub-Committee. The minutes of this meeting were not yet available, but certain of the suggestions made would now be referred to the Board for consideration.

Cart Road and Bridges.—The Chairman said the position in regard to the Mattakelle cart road was not altogether satisfactory. The Board had given an undertaking to maintain the road in good repair and the necessary steps to implicate this undertaking would be carried out as soon as the present abnormal heavy traffic, due to the building operations, was over. The Superintendent had been instructed to prepare estimates for the work.

New Clearings.—The Chairman reported that the Experimental Sub-Committee had supported the Visiting Agent's suggestions that these clearings should be manured.

The Chairman also called attention to Mr. Baillie-Hamilton's suggestion that "Acacia decurrens" should be planted out in the clearings. Mr. Ferguson was known not to favour the use of this tree and the Experimental Sub-Committee had in consequence recommended as a temporary measure that "Tephrosia vogelli" should be put in pending further discussion of the point after Mr. Ferguson's return. Both Messrs. Forbes and Horsfall said that they had found "Acacia decurrens" very satisfactory. After some discussion, the Board confirmed the recommendation of the Experimental Sub-Committee.

Manurial Policy.—Referring to the question of manures generally, Major Scoble Nicholson suggested that competitive quotations should be obtained for manures required for the estate, and the Board supported this proposal.

Mr. Roe asked at what time pruning mixture was applied and was informed by the Chairman that this was usually done about the time of pruning. Several members referred to the possible advantage of applying pruning mixtures before pruning. The Director, replying to these questions, said there were at present available no definite data as to the best time to apply pruning mixtures. The question was an important one to which he had already called attention, and the matter would certainly receive the consideration of the Scientific Staff.

Nurseries.—The Chairman called attention to the note in the current number of *The Tea Quarterly* describing the condition found in the nursery beds at St. Coombs, where there had been considerable trouble with unhealthy seedlings. The Director amplifying this note stressed that no evidence of fungus and insect pests had been found, and the trouble seemed chiefly to be due to the moisture conditions in the higher part of the slopes. Applications of manure had not proved helpful but when the rains set in, conditions had much improved. Before this surface watering had been relatively ineffective owing to the nature of the soil which easily caked forming a hard pan.

Considerable quantities of plants would be required for future openings, and the Board discussed the question as to whether further nurseries should be laid down at St. Coombs, or efforts made to secure stumps from elsewhere. In this connexion it was pointed out that there were many advantages in establishing nurseries in St. Coombs, particularly as this would facilitate the selection of suitable material for the experimental areas.

The Board decided that nurseries should be established at St. Coombs and asked the Visiting Agent and Superintendent to select a suitable site for these.

TEAS FOR THE LONDON MARKET.

The Chairman stated the proposal that the Institute's teas should be sold in London for a year had originated in a resolution proposed by Mr. P. G. Edwards, at a meeting of the Uva Planters' Association, and had been passed on to the Parent Association. He had referred the proposal to both the Visiting Agent and Superintendent, who were both of the opinion that the present crop was too small to receive the same attention on the London market that it did on the local one—an opinion which he personally and the other planting members of the Board were in agreement with.

When the matter was discussed by the Planters' Association at its last Committee Meeting, he had expressed these views, emphasising at the same time that the Board would, he felt sure, be in sympathy with the proposal and that when the crop from the estate shewed a material increase would be prepared to reconsider the matter.

The Chairman, continuing, reported that a few days prior to the meeting a letter had been received from Messrs. Geo. Steuart and Co., in the same connexion, which the Secretary would now read:—

Geo. Steuart & Co.,
Colombo, September 16th, 1930.

The Secretary, Tea Research Institute, Nuwara Eliya.

Dear Sir,—With reference to the suggestion recently put forward by Major Edwards, at a meeting of the Uva Planters' Association, to the effect that teas suitable for the London market, as well as for the Colombo market, should be made at St. Coombs, we are instructed by the London Secretaries of the Standard Tea Company of Ceylon, Ltd., for which we act as local agents, to give full support to this proposal.

The Standard Tea Company of Ceylon, Ltd., as a large London Company and a subscriber to the Tea Research Scheme rather feels, we gather, that the present tendency is to study local rather than London interests and perhaps you would be so good as to let us have your views on the subject.—We are, Dear Sir, Yours faithfully, Geo. Steuart and Co.

The Board supported the Chairman's view that it was not in the interests of the Institute to give effect to the suggestion made in the Uva Planters' Association's resolution for the present.

It was further decided that half chests of the three principal grades should be sent to the Ceylon Association in London, with the request that reports should be obtained from the leading brokers and buyers, connected with the London market.

The Chairman further reported that he had been informed that about half of the present crop sold on the local market was exported to London, the major part of the balance being bought for export to Australia and America.

SEWAGE DISPOSAL ESTIMATES.

The Board confirmed the Chairman's action in sanctioning the revised estimates drawn up on the advice of the Sanitary Engineer.

ELECTRIC LIGHT AND POWER CABLES.

The Chairman requested the Board's sanction for the expenditure for electric light and power cables at St. Coombs, viz., (1) Power House to Laboratory; (2) Continuation from Laboratory to senior

staff bungalows; (3) Power House to present junior staff bungalows; and (4) Extension of No. 3 to additional junior staff bungalow site.

The Board sanctioned the expenditure.

FACTORY EXPERIMENTS.

The Chairman said that several applications had now been received from firms and private individuals for the test of plant or systems of manufacture at St. Coombs Factory, and it was necessary for the Board to define its policy in dealing with such applications. The matter had been very fully discussed by the Experimental Sub-Committee which had decided to recommend to the Board the following procedure:—

(1) On receipt of such applications, the firm or individual concerned shall be requested to give facilities to the Institute Staff to visit a factory in which such plant or process is being worked and to take such observations as may seem necessary in order to assess the scope and value of the process. Such preliminary data will, of course, be confidential and not for publication.

(2) The Institute Staff will then report to the Experimental Sub-Committee who will consider the application in detail and make a recommendation to the Board as to whether the proposals should be entertained or not.

(3) The capital cost of installing any such plant should be met by the firm or individual desiring the test to be carried out, and, in the event of the tests being unfavourable, the firm or individual may be required to remove the plant, and, if necessary, restore the original conditions.

(4) In regard to all such work, the Institute will retain full liberty to publish in *The Tea Quarterly* or Institute bulletins all data obtained whether favourable or otherwise.

(5) In installing any such experimental plant, it would seem desirable to obtain a certificate from the firm or individual concerned that the installation as carried out meets their requirements in providing proper facilities for an adequate trial.

After full discussion the Board approved the recommendation of the Experimental Sub-Committee.

Experimental Machinery.—Reported that the two experimental rollers had now been shipped and were shortly expected in Ceylon.

One bank of tats had been constructed and work on the roll breaker and drier was well advanced. It was expected the experimental machinery would be installed about the end of the month.

LABORATORIES.

Reported that notice had been given terminating the leases of "Lindfield" and Mahagalla bungalows from December 31st, 1930.

The Director reported that work on the Laboratory had been delayed by the non-arrival of the acid-proof piping. It was anticipated that the building would be completed about the middle of December.

STAFF.

Senior Scientific Staff.—The annual increments due to Dr. Norris, Mr. Eden and Dr. Evan were approved.

Renewal of Dr. Evans' Agreement.—Reported that Dr. Evans was proceeding on leave early next year, and that his present agreement terminated on September 5th, 1931.

Resolved unanimously to renew Dr. Evans' agreement on the present terms for a further period of five years from September 6th, 1931. Decided that in the new agreement, Dr. Evans' official designation should be that of "Biochemist."

Junior Staff Provident Fund.—Reported that a simplified scheme for this fund was now under consideration and a further report would be submitted before the next meeting.

New Appointments.—Reported that Mr. D. G. de Zilva had been appointed as 2nd Clerk as from September 18th.

EMPIRE MARKETING BOARD.

The following letter from the Director of Agriculture was read:—

No. A2397, Department of Agriculture,
Peradeniya, 17-21 July, 1930.

(*Grant to the T. R. I. from the Empire Marketing Board.*)

Sir,—Adverting to correspondence ending with my letter No. A2115 of May 14th, 1929, I have the honour to forward herewith a copy of a letter received from Government on the subject of grant to the Tea Research Institute from the Empire Marketing Board.—I am, Sir, Your obedient servant, (Sgd.) W. Youngman, Director of Agriculture.

The Director, Tea Research Institute of Ceylon,
Nuwara Eliya.

No. A. 2/30, Colonial Secretary's Office,
Colombo, July 15th, 1930.

(*Grant to the T. R. I. from the Empire Marketing Board.*)

Sir,—With reference to your report No. A2395 of the 4th February, 1930, on the above subject, I am directed to forward herewith for your information a copy of despatch No. 303 of the 13th June, 1930, and its enclosures received from the Secretary of State for the Colonies, and to request you to inform the Tea Research Institute of the sanction by the Empire Marketing Board of a capital grant not exceeding £1,000 to the Institute for

the purchase of machinery and plant for the factory, payment to be claimed through this Government on detailed vouchers shewing the machinery, etc., purchased.

2. As regards the Institute's application for grant of £2,000 a year for three years for an investigation of the biological control of insect pests of tea and other crops you may inform them that the matter is still under consideration.—I am, Sir, Your obedient servant, (Sgd.) J. C. Jansz, for Colonial Secretary.

The Director of Agriculture, Peradeniya.

Reported that no further information had been received in regard to the application for a grant for parasite work.

TEA RESEARCH CONFERENCE.

On the suggestion of the Chairman, the following Sub-Committee was appointed to make arrangements for the T.R.I. Conference:

The Director, the Chairman, Mr. Forbes (Jnr.), and Mr. Huntley Wilkinson.

Attention was called by Mr. Baynham to the fact that the Census had now been fixed for February 26th and 27th, and it might therefore be necessary to change the date of the Conference.

CONTRACT FOR JUNIOR STAFF BUNGALOWS.

The Board confirmed the action of the Chairman in allotting to Messrs. Hemachandra and Co., the contract for the construction of Nos. 5 and 6 junior staff bungalows.

The meeting terminated with a vote of thanks to the Chair.

NOTICES.

The Institute's laboratories have now been transferred to St. Coombs and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station, c/o. Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Superintendent may not be free to show them round. Such visitors on arrival at the Factory are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the Mattakelle turn-off opposite culvert marked 28/10 on the Nanuoya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not* to the Director's Office.

ROLAND V. NORRIS.
Director.